VOL. 7

United States of America,
Northern District of Illinois,
Eastern Division. } ss.

IN THE

District Court of the United States

UNITED STATES OF AMERICA, *Complainant,* vs. THE SANITARY DISTRICT OF CHICAGO, *Defendant,*	C. C. No. 29,019 and Equity No. 114.

INDEX OF EXHIBITS OFFERED IN EVIDENCE BEFORE COMMISSIONERS APPOINTED TO TAKE TESTIMONY IN SAID CAUSE.

Appearances:

Mr. James H. Wilkerson,
United States Attorney, and
Mr. Albert L. Hopkins,
Assistant United States Attorney,
For Complainant.

Mr. Edmund D. Adcock and
Mr. Alfred S. Austrian,
For Respondent.

1914
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Chicago

VOL. VII.

CLASSIFIED TABLE OF CONTENTS—EXHIBITS.

Exhibits Attached to Bill of Complaint of the United States, No. 114.

Number	Name	Page
A	War Department Permit, May 8, 1899. Permits 200,000 cubic feet per minute	1
B	War Department Order, April 9, 1901. Orders observance of 1899 permit	2
C	War Department Letter, July 23, 1901. Grants 300,000 cubic feet per minute between hours of 4 p. m. and midnight	3
D	War Department Permit, December 5, 1901. Permits not to exceed 250,000 cubic feet per minute throughout 24 hours	4
E	War Department Permit, January 7, 1903. Permits 350,000 cubic feet per minute till March 31, 1903	5
F	Sanitary District Letter, February 5, 1912. Application for 10,000 C. F. S.	6
G	War Department Letter. Reply to application for 10,000 C. F. S.	7

Exhibits Attached to the Answer of the Sanitary District of Chicago.

A	Copy of Act of May 29, 1899, creating the Sanitary District, and amendments thereto	19
B	Outline map of Chicago River and branches	21
C	War Department Letter, March 14, 1907. Relates to reversal of flow of Calumet River	23
D	War Department Letter, September 11, 1907. Permit to construct north shore channel	26
E	War Department Letter, June 30, 1910. Permit to construct Calumet Sag channel	27
F	Memorial to Congress on the subject of the Illinois and Michigan Canal, Laws, Extra Session, 1826, p. 97	29
G	Ordinance (June 5, 1865) for cleansing Chicago River	31

243 987

Number	Name	Page
H	Sanitary District Letter, June 16, 1896. Application for improvement of Chicago River; also map of Chicago River accompanying same	31
I	War Department Letter, July 3, 1896. Permit for the improvement of Chicago River	37
J	Sanitary District Letter, April 26, 1900. Application for improvement of Chicago River	38
J1	Sanitary District Letter, June 7, 1900. Relative to improvement of Chicago River	39
K1 and K2	Maps of Chicago River, 18th to 31st streets. Sent to Secretary of War, June 7, 1900	41
L	War Department Letter, June 11, 1900. Permit to improve Chicago River	43
L1	War Department Letter, July 11, 1900. Permit to improve Chicago River	44
M	Map of Sanitary District of Chicago, 1913	47

CLASSIFIED TABLE OF CONTENTS—VII EXHIBITS.

Complainant's Exhibits.

Number	Name	Page
1	Discharge Curve—St. Clair River Increment=23,820 C. F. S.	49
2	Discharge Curve—St. Lawrence River Increment=28,870 C. F. S.	51
3	Discharge Curve—Niagara River International Bridge Section Increment=21,900 C. F. S.	53
4	Discharge Curve—Niagara River Open Section Increment=21,640 C. F. S.	55
5	Hydrograph (1860-1912, inclusive). Monthly water levels Lakes Superior, Michigan, Huron, Erie, Ontario	57

Defendant's Exhibits.

GARDNER S. WILLIAMS' EXHIBITS FOR DEFENDANT.

Number	Name	Page
1	General Chart of Lake Superior	59
2	Chart No. 3, St. Mary's River. Head of Hay Lake to Whitefish Bay	61
3	Chart No. 2, St. Mary's River. Twin Islands to Sault Ste. Marie	63
4	Chart No. 1, St. Mary's River. Lake Huron to Twin Islands	65
5	General Chart of Lake Michigan	67
6	General Chart of Lake Huron	69
7	Chart, St. Clair River, including foot of Lake Huron and St. Clair Flats Canal	71
8	Chart, Lake St. Clair	73
9	Chart of Detroit River	75
10	Chart, Lower Detroit River, showing Livingstone Channel	77
11	Chart, Lake Erie, including the waterways between Lakes Ontario and Huron	79
12	Chart, Buffalo Harbor and Niagara River to the Falls, New York	81
13	Chart, Niagara River from above the Falls to Lake Ontario	83
14	Chart, Lake Ontario	85
15	Chart No. 6, St. Lawrence River	87
16	Chart No. 5, St. Lawrence River	89
17	Chart No. 4, St. Lawrence River	91
18	Chart No. 3, St. Lawrence River	93
19	Chart No. 2, St. Lawrence River	95
20	Chart No. 1, St. Lawrence River	97
21	Seven (7) sheets, containing the U. S. Lake Survey Discharge Measurements of the St. Clair River, Dry Dock Section, 1899, 1900, 1901, 1902, 1908	99-105
22	Six (6) sheets, containing U. S. Lake Survey Records of St. Clair River, as follows	106-111
	Sheet 1. Mean Slope, November-December, 1908	106
	Sheet 2. Summary of 1908 Gorge Section Discharge Measurements	107
	Sheet 3. Summary of 1908 Dry Dock Section Discharge Measurements	108
	Sheet 4. Discharge Measurements, Gorge Section, 1908, 1909	109
	Sheet 5. Same as Sheet 4, 1909	110
	Sheet 6. Discharge Measurements, Dry Dock Section, 1908	111

GARDNER S. WILLIAMS' EXHIBITS FOR DEFENDANT.

Number	Name
23	Thirty-seven (37) sheets containing U. S. Lake Survey Records of St. Clair River, as follows.....112- Sheets 1-9, incl., Daily Mean Water Surface Elevations .....11 Sheet 10. Observation on Time of Travel of Wave. Sheets 11-14. Discharge Measurements George Section, 1910 .....12 Sheet 15. Discharge Measurements Dry Dock Section, 1910 ..... Sheets 16-22. Summary Discharge Measurements. Delta Section .....12 Sheets 23-25. Sketches showing location of Sections and Gages on St. Clair River.....13 Sheet 26. Curves of Local Slope Head of River.... Sheet 27. Discharge Curve St. Clair River. Increment = 35,145 ..... Sheets 28-31. Current Velocity curves showing effect of passing vessels.....13 Sheets 32-37. Cross Sections. Delta Sections....14
24	Five (5) sheets containing summary of discharges of Niagara River, 1898, 1899, 1900.....14
25	Two (2) sheets containing summary of discharges of St. Lawrence River, 1900, 1901.....154-155
26	Six (6) tables giving Monthly Mean Elevations of Water Surface of Lakes Superior, Michigan, Huron, St. Clair, Erie and Ontario, 1860-1913 inclusive.....156-16
27	Three (3) tables giving Monthly Mean Elevations of Water Surface, as follows.....168-170 Table 1. Detroit River at Amherstburg, Ont. Table 2. Lake St. Clair at Windmill Point. Table 3. Detroit River at Fort Wayne.
28	Eight (8) sheets of Daily Mean Elevations of Water Surface, Lakes St. Clair and Huron, during periods of discharge measurements 171-17
29	Nineteen (19) sheets of Daily Mean Elevations of Water Surface as follows .....181-18 Sheets 1-7 incl.., Amherstburg, Ont., 1898, 1899, 1900, 1909, 1910. Sheets 8-14 incl., Cleveland, Ohio, 1898, 1899, 1900, 1909, 1910. Sheets 15-29 incl., Buffalo, N. Y., 1898, 1899, 1900, 1901, 1902, 1909, 1910.

GARDNER S. WILLIAMS' EXHIBITS FOR DEFENDANT.

Number	Name	Page
30	Five (5) sheets of Daily and Monthly Mean Elevations of Water Surface, as follows	201-205
	Sheet 1. Miscellaneous Automatic Gage Records.	
	Sheets 2-3 incl. Daily, Oswego Records, 1900, 1901.	
	Sheets 4-5 incl. Daily, Ogdensburg Records, 1900, 1901.	
31	Seven (7) tables giving the mean monthly and annual rainfall on Lakes Superior, Michigan, Huron, Erie and Ontario, 1895-1906	206-210
32	Pages 2855-2883, Appendix FFF 2, Annual Report Chief of Engineers for 1903, being the Report of E. S. Wheeler upon Outflow, Rainfall and Evaporation in the Valley of Great Lakes	211-247
33	Report of the International Waterways Commission on Regulation of Lake Erie, 1910	248-347
34	Consisting of a series of 65 Tables, 6 Charts and 11 Plates based on Williams Exhibits 1 to 33 incl., and 35 in this case, and the Records of United States Lake Survey, Reports of the Chief of Engineers, U. S. A., of the United States Geological Survey and of the United States Weather Bureau; and of Officials of certain States and Municipalities. (For Index See VII, 350-355)	349-547
35	Five (5) Charts of Plottings of Daily Mean Elevation of Water Surface, as follows	548-567
	Chart I. Lakes Huron and St. Clair, 1889, 1900, 1901	548-550
	Chart II. Lakes Huron and St. Clair, 1908, 1909, 1910	550-555
	Chart III. Lake Erie at Cleveland, 1898, 1899, 1900	556-560
	Chart IV. Lake Erie at Buffalo, 1898, 1899, 1900	561-565
	Chart V. Lake Ontario, Ogdensburg and Oswego, 1900, 1901	566-567

FREDERICK P. STEARNS' EXHIBITS FOR DEFENDANT.

1	Seven (7) tables as follows	568-574
	Table A, Local Supply and Storage, Lake Ontario	568
	Table B, Local Supply and Storage, Lakes St. Clair and Erie	569
	Tables C and D, Niagara River Discharge Deduced from St. Lawrence River Discharge	570, 571

FREDERICK P. STEARNS' EXHIBITS FOR DEFENDANT.

Number	Name	Page
	Tables E and F, St. Clair River deduced from Niagara River	572, 573
	Table G, Comparisons of Discharges St. Lawrence and St. Clair Rivers	574
2	Four (4) charts, being plottings of following	575-581
	Chart 1. Stearns Exhibit 1, Table C	575
	Chart 2. Stearns Exhibit 3	577
	Chart 3. Stearns Exhibit 1, Table F	579
	Chart 4. Stearns Exhibit 1, Table E	581
3	Table giving Niagara Discharge deduced from St. Lawrence 1912 Discharge Curve	583

JOHN R. FREEMAN'S EXHIBITS FOR DEFENDANT.

1	Studies Relative to Chicago Drainage Canal	585
2	Reproduction of Record of U. S. L. S. Gauge No. 5, for May 17, 1899, at Head of St. Clair River	587
3	Hydrographs of Lakes Huron, St. Clair and Erie and Fall of Detroit and St. Clair Rivers, 1873-1898	588
4	Article of B. F. Groat on Current Meters, Paper No. 1259, Transactions Am. Soc. C. E.	589-654
5	Plotting Illustrating Time Interval between gages on St. Clair River	655
6	Plotting showing change in current velocity following fluctuations in water level	656
7, 8 and 9	Plotting showing pulsations of current at Section Dry Dock	657-659

HENRY C. ADAMS' EXHIBITS FOR DEFENDANT.

1	Chicago Death Rates—All causes, 1887-1912	661
2	Plotting of Chicago Death Rates, 1860-1912	662
3	Table comprising death rates—Impure air diseases and impure water diseases, 1887-1912	663
4	Distribution of deaths from Typhoid by sex and age	664
5	Decrease in death rates since opening of Drainage Canal	665
6	Map of Manufacturing Zone of Chicago	666
7 & 8	Federal Forms for reporting boat record	667, 668
9	Plotting of prices of pig iron and rails in Pennsylvania, 1895-1911	669
10	Comparison average monthly prices heavy steel rails in England and United States, 1895-1911	671
11	Plotting average prices light and heavy steel, 1895-1911	673
12	Plotting average prices iron and steel, 1895-1911	675
13	Summary Table of loss that would be sustained by Chicago were present facilities for pure water impaired or destroyed	677

Number	Name	Page
	GEORGE W. FULLER'S EXHIBITS FOR DEFENDANT.	
1	Map of Sanitary District Boundary and the corporate limits of Chicago	679
	KENNETH B. TURNER'S EXHIBITS FOR DEFENDANT.	
1	Vertical Velocity Curves, St. Mary's River	681
	ERNEST W. SCHODER'S EXHIBITS FOR DEFENDANT.	
1	Photograph of Haskell Current Meter	683
2-12 (incl.)	Photographs of Cornell University Canal	684-694
13	Table of Discharge Measurements by Haskell Current Meter in Cornell University Hydraulic Laboratory	695
	GEORGE M. WISNER'S EXHIBITS FOR DEFENDANT.	
1	Map showing the limits of the Sanitary District of Chicago.	697
2	Map showing parts of Cook, Will and DuPage Counties and the Sanitary District	699
3	Chart showing saving to community by reduction of Typhoid Fever since opening of Drainage Canal	701
4	Plotting of Typhoid Fever Death Rates at Chicago, East Chicago, Hammond and Whiting	703
6	Hydrograph average monthly elevation water surface Lake Michigan, 1889-1899 and 1900-1910	705
	Complainant's Exhibits in Rebuttal.	
	WALDEMAR S. RICHMOND'S EXHIBITS FOR COMPLAINANT.	
1	Report of W. S. Richmond on Discharge of Niagara River at Split Section	707-709
2	Still Water Rating Curves of U. S. Lake Survey Current Meters	711
3	Niagara Discharge Plotted against Buffalo Gage	713
4	Cross Sections Wickwire and Oakfield and Transverse Velocity Curves	715
	SHERMAN MOORE'S EXHIBITS FOR COMPLAINANT.	
1-4 (incl.)	Discharge Measurements Chicago Drainage Canal, Lemont, Illinois, Feb. 5, 1914	717-720
5	Mean 24 hour Curve of Flow, Chicago Drainage Canal, Lemont, Ill.	721
	FRANCIS C. SHENEHON'S EXHIBITS FOR COMPLAINANT.	
A	Plotting of Discharge Measurements and lines for increments 34,000 and 21,600 C. F. S.	723

FRANCIS C. SHENEHON'S EXHIBITS FOR COMPLAINANT.

Number	Name	Page
B	Plotting of Increment of Niagara—21,900 C. F. S. (Bridge Section), and lines showing departure of one, two and three per cent	725
C	Plotting of 30 Measurements of Niagara River (Bridge Section), used by G. S. Williams, also winter measurements included by mistake	727
D	Same as B, only using Open Section Measurements and Increment = 21,640 C. F. S.	729
D-1	Plotting of 89 Measurements of Niagara River (Open Section, used by G. S. Williams	731
E	Plotting Equations of Discharge Suspension Bridge and Whirlpool	733
F	Plotting of Discharge Curve of Niagara River Suspension Bridge Gage	735
G	Plotting of Discharge Curve of Niagara River Whirlpool Gage	737
H	Plotting of Relative Fluctuations of Whirlpool and Gorge Pool Gages	739
I	Plotting of Relative Fluctuations of Water Surfaces, Lakes Huron and St. Clair	741
J	Plotting of Relative Fluctuations of Water Surfaces, Lakes Erie and Ontario before and after Gut Dam	743
K	Three Curve Series—Sheet 1—Water Level and Discharge Curves, Lake Erie and Niagara River	745
L	Three Curve Series—Sheet 2	747
M	Three Curve Series—Sheet 3	749
N	Three Curve Series—Sheet 4	751
O	One Curve Series—Sheet 1—Water Level and Discharge Curves, Lake Erie and Niagara River	753
P	One Curve Series—Sheet 2	755
Q	One Curve Series—Sheet 3	757
R	Curves showing observed and computed Elevations, Lakes Michigan, Huron, Erie, Ontario (also Complainant's Exhibit "A")	759
S	Discharge Curve St. Lawrence River, Sherman Moore, 1912	761
T	Comparison of St. Lawrence (1912), Discharge with Niagara Discharge, Complainant's Equation	763
U1 U2 U3 U4 U5	A series of sheets of computations establishing the Increment of the Niagara River	765-769
V	Curves showing observed and computed Elevations of Niagara River by Chippawa Gage	771

Defendant's Exhibits in Surrebuttal.

George M. Wisner's Exhibits for Defendant.

Number	Name	Page
7, 8, 9, 10, 11	Five (5) maps of the Chicago River from Lake Michigan through the main branch and south and west on the south branch to Ashland Avenue	733-781
12	Outline of Docks along Chicago River from 18th Street to Pennsylvania Railroad, prior to improvements	783
13	Same as Wisner Exhibit 12—Subsequent to improvement	785
14A	Curves of Flow at Power House and Controlling Works during Test of February 22 and 23, 1914	787
14B	Curves of Flow at Power House, Lemont, Summit and Dearborn Streets, Feb. 22, 23, 1914	788
14C	Water Levels in Main Channel and Chicago River, Feb. 22, 23, 1914	789

George M. Wisner's Exhibits for Defendant.

14D, E, & F.	Correspond to 14A, 14B and 14C for Test of March 8 and 9, 1914	790-792

Gardner S. Williams' Exhibits for Defendant.

36	Direction Measurements of Vertical Curves, International Bridge, Niagara River	793
37	Field Data on Vertical Curve, Span 6, Station 4/12 International Bridge	796
38	Plotting Vertical Curves, Niagara River, Sectional Oakfield, Vertical 8	797
39A, B	Plotting Hourly Water Levels, Buffalo and Chippawa, Nov., 1906	799, 801
39C, D	Table of Direction Measurements on Vertical Curves, Niagara River	802-805
39E1, E2, E3, E4	Plotting Buffalo Gage, Computed from Chippawa	807-813
40	Diagram giving analysis of method used for locating Direction Meter A, at tenths of depth	815
41	Discharge Measurements (Records), Niagara River (1907-1908)	817-821
42	Hourly Water Levels, Nov., 1906 (Table), Buffalo and Chippawa	822-829

SPECIAL CROSS INDEX OF U. S. EXHIBITS.

Page of printed record	Page of folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
7	49	Ex. 1, Feb. 15, '09	U. S. Ex. No. 1	7	Lowering Michigan-Huron
9	49	Ex. 1, Feb. 15, '09	U. S. Ex. No. 1		Lowering Michigan-Huron
10	51	Ex. 2, Feb. 15, '09	U. S. Ex. No. 2	10	Lowering St. L. R.
10	53	Ex. 3, Feb. 15, '09	U. S. Ex. No. 3	10	Lowering Lake Erie
10	55	Ex. 4, Feb. 15, '09	U. S. Ex. No. 4	10	Lowering Lake Erie
12	49	Ex. 1, Feb. 15, '09	U. S. Ex. No. 1	7	
12	51	Ex. 2, Feb. 15, '09	U. S. Ex. No. 2	10	
12	53	Ex. 3, Feb. 15, '09	U. S. Ex. No. 3	10	
12	55	Ex. 4, Feb. 15, '09	U. S. Ex. No. 4	10	
28	49	Government Ex. 1	U. S. Ex. No. 1	7	
28	51	Government Ex. 2	U. S. Ex. No. 2	10	
28	53	Government Ex. 3	U. S. Ex. No. 3	10	
28	55	Government Ex. 4	U. S. Ex. No. 4	10	
45	49	Complainant's Ex. 1	U. S. Ex. No. 1	7	
45	51	Complainant's Ex. 2	U. S. Ex. No. 2	10	
45	53	Complainant's Ex. 3	U. S. Ex. No. 3	10	
45	55	Complainant's Ex. 4	U. S. Ex. No. 4	10	
46	49	Government Ex. 1	U. S. Ex. No. 1	7	
46	51	Government Ex. 2	U. S. Ex. No. 2	10	
46	53	Government Ex. 3	U. S. Ex. No. 3	10	
46	55	Government Ex. 4	U. S. Ex. No. 4	10	
46	49	Haskells Ex. 1 for Ident.	Same	46	Introduced by Deft.
54	49	Haskells Ex. 1	Same	46	
55	49	Government Ex. 1	U. S. Ex. No. 1	7	
55	51	Government Ex. 2	U. S. Ex. No. 2	10	
55	53	Government Ex. 3	U. S. Ex. No. 3	10	
55	55	Government Ex. 4	U. S. Ex. No. 4	10	
56	49	Haskells Ex. 1	Haskells Ex. 1	46	
56	49	Haskells Ex. 1	Haskells Ex. 1	46	
73	57	Comp. Ex. No. 5 (Apr. 19, '09)	Same	73	General chart of Great Lakes, not in folio
95	49	Complainant's Ex. 1	U. S. Ex. No. 1	7	
102	53	Complainant's Ex. 3	U. S. Ex. No. 3	10	
102	55	Complainant's Ex. 4	U. S. Ex. No. 4	10	
106	51	Complainant's Ex. 2	U. S. Ex. No. 2	10	
163	49	Government Ex. 1	U. S. Ex. No. 1	7	
167	51	Government Ex. 2	U. S. Ex. No. 2	10	
163	53	Government Ex. 3	U. S. Ex. No. 3	10	
163	55	Government Ex. 4	U. S. Ex. No. 4	10	
164	49	Exhibit No. 1	U. S. Ex. No. 1	7	
171	51	Exhibit No. 2	U. S. Ex. No. 2	10	
182		Statistical report of Lake Commerce, 4/21/09	Same		Not printed

Page of printed record	Page of folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
186	49	Exhibit No. 1	U. S. Ex. No. 1	7	
195	49	Exhibit No. 1	U. S. Ex. No. 1	7	
228	49	Compl. Ex. No. 1	U. S. Ex. No. 1	7	
232	51	Compl. Ex. No. 2	U. S. Ex. No. 2	10	
233	53	Compl. Ex. No. 3	U. S. Ex. No. 3	10	
233	55	Compl. Ex. No. 4	U. S. Ex. No. 4	10	
249	57	Ex. No. 5, May 24, '09	249 Hydrography		
			7 Lowering Michigan-Huron		U. S. Ex. No. 5
287	49	Compl. Ex. No. 1			U. S. Ex. No. 1
			10 Lowering St. L. R.		
	51	Compl. Ex. No. 2	10 Lowering Lake Erie		U. S. Ex. No. 2
	53	Compl. Ex. No. 3	10 Lowering Lake Erie		U. S. Ex. No. 3
	55	Compl. Ex. No. 4	7 Described		U. S. Ex. No. 4
289	49	Compl. Ex. No. 1			U. S. Ex. No. 1
			To be furnished Deft		
291		Tables	7 Described		
294	49	Exhibit No. 1	10 Described		U. S. Ex. No. 1
294	51	Exhibit No. 2	10 Described		U. S. Ex. No. 2
294	53	Exhibit No. 3	10 Described		U. S. Ex. No. 3
294	55	Exhibit No. 4	10 Explained		U. S. Ex. No. 4
295	51	No. 2	10 Explained		U. S. Ex. No. 2
295	53	No. 3	10 Explained		U. S. Ex. No. 3
295	55	No. 4	7		U. S. Ex. No. 4
296	49	Plat No. 1	10		U. S. Ex. No. 1
300	53	Ex. No. 3	10		U. S. Ex. No. 3
301	55	Ex. No. 4	10		U. S. Ex. No. 4
303	53	Ex. No. 3	10		U. S. Ex. No. 3
303	55	Ex. No. 4	10		U. S. Ex. No. 4
307	51	Ex. No. 2	7		U. S. Ex. No. 2
308	49	Ex. No. 1			U. S. Ex. No. 1
308	51	Ex. No. 2	U. S. Ex. No. 2	10	
308	53	Ex. No. 3	U. S. Ex. No. 3	10	
308	55	Ex. No. 4	U. S. Ex. No. 4	10	
310		Ex. No. 6, for identification	Not printed		Current meter test
			Chapter 16 of Report on Preservation of Niagara Falls. Senate document No. 105, 61st Cong. 1st sess.		
355	57	Hydrograph	U. S. Ex. No. 5	249	
361	57	Exhibit No. 5	U. S. Ex. No. 5	249	
367	49	Government Ex. 1	U. S. Ex. No. 1	7	
747	51	Compl. Ex. 2	U. S. Ex. No. 2	10	
749	53	Ex. 3	U. S. Ex. No. 3	10	
749	55	Ex. 4	U. S. Ex. No. 4	10	
803	49	Haskells Ex. 1	Same	46	
803	53	Compl. Ex. 3	U. S. Ex. No. 3	10	
846	53	Williams' Cross Ex. No. 1	Same	846	P. N. F. Discharges

Page in printed record	Page in folio of exhibits	Description used in text o. testimony	Description used in folio of exhibits	Page introduced	Remarks
847	53	Williams' Cross Ex. No. 1	Same	846	
848	53	Williams' Cross Ex. No. 1	Same	846	
849	53	Williams' Cross Ex. No. 1	Same	846	
850	53	Williams Cross Ex. No. 1	Same	846	
851	53	Williams' Cross Ex. No. 1	Same	846	
852	53	Williams' Cross Ex. No. 1	Same	846	
853	53	Williams' Cross Ex. No. 1	Same	846	
854	53	Williams' Cross Ex. No. 1	U. S. Ex. No. 3	846	
855	53	Williams' Cross Ex. No. 1	Same	846	
857	53	Williams' Cross Ex. No. 2	Same	857	Photo (Gage Records)
861	53	Williams' Cross Ex. No. 2	Same	857	
862	53	Williams' Cross Ex. No. 2	Same	857	
863	53	Williams' Cross Ex. No. 1	Same	846	
864	53	Comp. Ex. 3	Same	10	
880	723	Williams' Cross Ex. No. 3	Shenehon's Ex. A	880	
881	723	Williams' Cross Ex. No. 3	Shenehon's Ex. A	880	
882	765-60	Williams' Memo. Cross Ex. A	Shenehon's Ex. U1 to U5	882	Comp. Three PX
892	53	Governments' Ex. No. 3	U. S. Ex. No. 3	10	
897		Williams' Ex., Cross Ex. No. 4		897	Photo, Buffalo & Chippawa Gage
898		Williams' Ex., Cross Ex. No. 4		897	
933	750	Comp. Ex. A. for identification Oct. 8/13	Shenehon's Ex. R, April 15, 1914	933	Red & Blue
934		Comp. Ex. A for identification Oct. 8/13		933	

Page o. printed record	Page o. folio of exhibits	Description used in text o. testimony	Description used in rolls o. exhibits	Page introduced	Remarks
943	741	Comp. Ex. B. for identification Oct. 8/13	Shenehon's Ex. 1, April 15, 1914	943	Huron, St. Clair Fluctuation
947	707	Governments' Ex. C for identification Oct. 8/13	Richmond's Ex. 1, Feb. 4, 1914	947	Richmond's Report, 1914
947	711	Governments' Ex. D for identification Oct. 8/13	Richmond's Ex. 2, Feb. 4, 1914	947	Richmond's Ratings
947	713	Governments' Ex. E for identification Oct. 8/13	Richmond's Ex. 3, Feb. 4, 1914	947	Discharge Curves
948	745	Governments' Ex. F for identification Oct. 8/13	Shenehon's Ex. K, April 15, 1914	948	Three Curve Series
948	747	Governments' Ex. G for identification Oct. 8/13	Shenehon's Ex. L, April 15, 1914	948	Three Curve Series
948	749	Governments' Ex. H for identification Oct. 8/13	Shenehon's Ex. M, April 15, 1914	948	Three Curve Series
948	751	Governments' Ex. I for identification Oct. 8/13	Shenehon's Ex. N, April 15, 1914	948	Three Curve Series
949	753	Governments' Ex. J for identification Oct. 8/13	Shenehon's Ex O, April 15, 1914	949	One Curve Series
949	755	Governments' Ex. K for identification Oct. 8/13	Shenehon's Ex. P, April 15, 1914	949	One Curve Series
949	757	Governments' Ex. L for identification Oct. 8/13	Shenehon's Ex. Q, April 15, 1914	949	One Curve Series
949	741	Governments' Ex. B Oct. 8, 1913	Shenehon's Ex. I, April 15, 1914	943	Fluctuation Huron-St. Clair
955	707	Comp. Ex. C	Richmond's Ex. 1	947	Report Split Section
966	745	Comp. Ex. F	Shenehon's Ex. K	948	Three Curve Series
966	747	Comp. Ex. G	Shenehon's Ex. L	948	Three Curve Series
966	749	Comp. Ex. H	Shenehon's Ex. M	948	Three Curve Series
966	751	Comp. Ex. I	Shenehon's Ex. N	948	Three Curve Series
969	745	Ex. F	Shenehon's Ex. K	948	Three Curve Series
969	747	Ex. G	Shenehon's Ex. L	948	Three Curve Series
969	749	Ex. H	Shenehon's Ex. M	948	Three Curve Series
969	751	Ex. I	Shenehon's Ex. N	948	Three Curve Series
970	755	Ex. K	Shenehon's Ex. P	948	One Curve Series
970	749	Ex. H	Shenehon's Ex. M		Three Curve Series
974	747	Ex. G	Shenehon's Ex. I	948	Three Curve Series

Page in printed record	Page in folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
975	747	Ex. L	Shenehon's Ex.	949	One Curve Series
976	745	Ex. F	Shenehon's Ex. K	948	Three Curve Series
977	755	Ex. K	Shenehon's Ex. P	949	One Curve Series
1143	763	Ex. N	Shenehon's Ex. T	1207	Table of Consistences
1196	723	"This chart"	Shenehon's Ex. A	880	
1200	757	Ex. L	Shenehon's Ex. Q	949	One Curve Series, Sheet 3
1200	349	Table XLV a	Williams' Ex. 34		
1202	753	"Charts produced"	Shenehon's Ex. O, P, Q	949	One Curve Series, Sheet 3
1203	723	Exhibit ——	Shenehon's Ex. A	880	Niagara Observation
1207	763	Governments' Ex. L	Shenehon's Ex. T	1207	Table of Consistencies
1208		"Map"	Map of Niagara River		Not printed
1214	763	Governments' Ex. M	Shenehon's Ex. T	1207	Table of Consistencies
1216	761	Blue Print of curves	Shenehon's Ex. S	1216	St. L. Curves
1219	745	Exs. F, G, H and L	Shenehon's Exs. K, L, M, N	948	Three Curve Series
1220	745	Chart 4, Sheet 1	Shenehon's Ex. K	948	Three Curve Series
1222	745	Ex. K	Shenehon's Exs.	948	One Curve Series
1224	743	Comp. Ex. N for identification	Shenehon's Ex. J April 15, 1914	1224	Characteristic change
1226	741	Defts. Ex. B	Shenehon's Ex. I	943	Huron & St. Clair
1235	763	Ex. N	Shenehon's Ex. T	1207	Table of Consistency
1236		Governments' Ex. H. H., Oct. 14, 1913		1236	Buffalo, Gage Readings
1239	723	"An Exhibit"	Shenehon's Ex. A	880	
1239	723	"That diagram"	Shenehon's Ex. A	880	
2660	725	Haskell's Ex. 1, Feb. 3/14	Shenehon's Ex. B	2660	
2667		Haskell's Ex. 2, Feb. 3/14 for identification		2667	Catalogue of Ritchie Haskell Meter not in record
2668	589	Groat's article	Freeman's Ex. 4	1183	
2900	683	Ex. 2, 3, 4, 5, 6, 8, 9, 10	Schoder's Exhibits	1536	
2873	589	Groat's report	Freeman's Ex. 4	1183	
2748		Haskell's Ex. 2			Haskell-Ritchie Catalog
2799	725	Haskell's Ex. 1, Feb. 3, 1914	Shenehon's Ex. B, April 15, 1914	2660	

Page of printed record	Page of folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
2806	739	Ray's Ex. 1, Feb. 4, 1914	Shenehon's Ex. H	2806	
2806	735	Ray's Ex. 2, Feb. 4, 1914	Shenehon's Ex. F	2806	
2806	737	Ray's Ex. 3, Feb. 4, 1914	Shenehon's Ex. G	2806	
2807		Ray's Ex.	Same as above		
2808		Ray's Ex.	Same as above		
2809		Ray's Ex.	Same as above		
2817	49-55	Comp. Ex. 1 to 4	U. S. Ex. 1 to 4	7-10	
2818	49-55	Comp. Ex. 1 to 4	U. S. Ex. 1 to 4	7-10	
2848		Comp. Ex. 1 to 4	U. S. Ex. 1 to 4	7-10	
2867	739	Ray's Ex. 1, 2, 3	Shenehon's Ex. H, F, G		
2884 to 2890		Moore's Ex. 1, 2, 3, 4, 5	Printed in record		
2939	707	Ex. C, Oct. 8, 1913	Richmond's Ex. 1, Feb. 4, 1914	947	Report Split Sec. of Niagara River
2940		Richmond's Ex. 1	Richmond's Ex. 1, Feb. 4, 1914	947	
2940	711	Ex. D, Oct. 8, 1913	Richmond's Ex. 2, Feb. 4, 1914	947	Plat at Rating Curve
2941	713	Ex. E, Oct. 8, 1913	Richmond's Ex. 3, Feb. 4, 1914	947	Disch'ge Curve Split Section
2941	715	Richmond's Ex. 4, Feb. 4, 1914	Richmond's Ex. 4	2941	
2946	725	Haskell's Ex.	Shenehon's Ex. B	2660	
2966		Richmond's Ex. A, Cross-ex. Feb. 18, 1914	Shenehon's Ex. B	2966	21 sheets Vertical Curves
3085		"Three blue prints"	Not offered as Ex.	294	Discharge Tables
3085		"Two sheets"	Not offered as Ex.		Discharge Tables
3085	765-69	"Five sheets"	Shenehon's Ex. U1-U5, incl.		Computations—3-Point Method
3086		Hayford's Ex. 1 to 5, incl., April 10, 1914	Shenehon's Ex. U1-U5, incl.		Computations—3-Point Method
3086	745	Ex. F, G, H, I	Shenehon's Ex. K, L, M, N, April 15, 1914	948	Three Curve Series
3086	753	Ex. J, K, L	Shenehon's Ex. O, P, Q, April 15, 1914	949	One Curve Series
3086	733	Hayford's Ex. 6, April 10, 1914	Shenehon's Ex. E, April 15, 1914	3086	Discharge Niagara at Whirlpool and Sus. Bridge

Page of printed record	Page or folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
3087	729	Hayford's Ex. 7, April 10, 1914	Shenehon's Ex. D, April 15, 1914	3087	Discharge Niagara Open Section
3087	725	Hayford's Ex. 8	Shenehon's Ex. B, April 15, 1914	2660	Discharge Niagara Bridge Section
3089	589	"Article by Gronte"	J. R. F. Ex. 4	1183	Groat's paper
3093	765	Hayford's Ex. 1, 2, 3, 4, 5	Shenehon's Ex. U1-U5		
3100		Williams' Ex. 24	Tables produced by Shenehon	291	
3108		Hayford's Ex. A, Cross-ex. April 10, 1914			Three sheets corrected discharge measurements.
3113	723	Ex. 3—Williams' Cross	Shenehon's Ex. A, April 15, 1914	880	Niagara discharge plat
3114		Shenehon's Ex. A, April 15, 1914	Same	880	Same
3114	725	Haskell's Ex. 1	Shenehon's Ex. B, April 15, 1914	2660	Discharge chart Observation Bridge Section Niagara
3115	725	Shenehon's Ex. B	Same	2660	Same
3116	53	U. S. Ex. 3	U. S. Ex. 3	10	
3117	53	Shenehon's Ex. C, April 15, 1914	Same	3117	Williams' Selected Obs. Bridge Sec.—Niagara
3117	725	Exhibit B	Shenehon's Ex. B		See above
3118	725	Shenehon's Ex. C	Same		See above
3118	729	Shenehon's Ex. D	Shenehon's Ex. D, April 15, 1914	3087	Discharge observations. Open Section Niagara
3118	729	Hayfords Ex. 7	Shenehon's Ex. D	3087	See above
3119	733	Shenehons Ex. E	Shenehon's Ex. E, April 15, 1913	3086	Discharge Curves. Whirlpool & Suspension Bridge
3119	733	Hayford's Ex. 6	Shenehon's Ex. E	3086	See above
3120	733	Shenehon's Ex. E	Shenehon's Ex. E	3086	See above
3120	735	Shenehon's Ex. F	Shenehon's Ex. F, April 15, 1914	2806	Discharge Curve for Suspension Bridge
3120	735	Ray's Ex. 2	Shenehon's Ex. F	2806	
3120		Shenehon's Ex. G	Shenehon's Ex. G, April 15, 1914	2806	Discharge Curve for Whirlp'l Niagara
3120	737	Ray's Ex. 3	Shenehon's Ex. G	2806	See above
3121		Shenehon's Ex. G	Shenehon's Ex. G	2806-3121	See above Curve of Gorge Relations
3121	739	Shenehon's Ex. H	Shenehon's Ex. H, April 15, 1914	2806	Cleveland Sus. Bridge Whirlpool

Page of printed record	Page of folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
3121	739	Ray's Ex. I	Shenehon's Ex. H	2806	See above
3122	739	Shenehon's Ex. H	Shenehon's Ex. H	2806	See above
3122	741	Shenehon's Ex. I	Shenehon's Ex. I, April 15, 1914	943	Table of Consistence
3122	741	Freeman's Ex. 13	Shenehon's Ex. I	943	Table of Consistence
3122		Shenehon's Ex. J	Shenehon's Ex. J, April 15, 1914	1224	Characteristic Change in Ontario Level
3122	743	U. S. Ex. N	Shenehon's Ex. J	1224	See above
3123		Shenehon's Ex. J	Shenehon's Ex. J	1224	
3123	745	Shenehon's Ex. K	Shenehon's Ex. K, April 15, 1914	948	Three Curve Series
3123	747	Shenehon's Ex. L	Shenehon's Ex. L, April 15, 1914	948	Three Curve Series
3123	749	Shenehon's Ex. M	Shenehon's Ex. M, April 15, 1914	948	Three Curve Series
3123	751	Shenehon's Ex. N	Shenehon's Ex. N, April 15, 1914	948	Three Curve Series
3123	745	Comps. Ex. F	Shenehon's Ex. K	948	Three Curve Series
3123	747	Comps. Ex. G	Shenehon's Ex. L	948	Three Curve Series
	749	Comps. Ex. H	Shenehon's Ex. M	948	Three Curve Series
	751	Comps. Ex. I	Shenehon's Ex. N	948	Three Curve Series
	745	Three Curve Series, 1-4	Shenehon's Ex. K, L, M, N	948	
3123	53	U. S. Ex. 3	U. S. Ex. 3	10	
	725	Shenehon's B and C	Shenehon's Ex. B and C	2660	
3124	745	Shenehon's Ex. K, L, M, N	Shenehon's Ex. K, L, M, N	948	
	753	Shenehon's Ex. O, P, Q	Shenehon's Ex. O, P, Q, April 15, 1914	949	One Curve Series
	753	Comps. Ex. J. K, L	Shenehon's Ex. O, P, Q	949	One Curve Series
	753	One Curve Series	Shenehon's Ex. O, P, Q	949	One Curve Series
3125	753	Shenehon's Ex. O, P, Q	Shenehon's Ex. O, P, Q	949	One Curve Series
	759	Shenehon's Ex. R	Shenehon's Ex. R, April 15, 1914	933	Red and blue
	759	Comps. Ex. A	Shenehon's Ex. R	933	Red and blue
3126	759	"The red and the blue"	Shenehon's Ex. R	933	Red and blue
	759	Shenehon's Ex. R	Shenehon's Ex. R	933	Red and blue
3127	761	Shenehon's Ex. S	Shenehon's Ex. S April 15, 1914	1216	

Page of printed record	Page or folio of exhibits	Description used in text o. testimony	Description used in folio of exhibits	Page introduced	Remarks
3127	761	Stearns' Ex. O	Shenehon's Ex. S	1216	
3127	763	Shenehon's Ex. T	Shenehon's Ex. T, April 16, 1914	1207	Table of Consistencies
	763	U. S. Ex. M	Shenehon's Ex. T	1207	Table of Consistencies
	761	Shenehon's Ex. S	Shenehon's Ex. S	1216	
3128	53	U. S. Ex. No. 3	U. S. Ex. No. 3	10	
	763	Shenehon's Ex. T	Shenehon's Ex. T	1207	Table of Consistencies
	765	Shenehon's Ex. U1,	Shenehon's Ex. U1,	882	Three Point Computations
	767	U2, U3, U4, U5	U2, U3, U4, U5, April 16, 1914		
	765-69	Hayford's Ex. 1, 2, 3, 4, 5	Shenehon's Ex. U1 to U5	882	Three Point Computations
3129	765-69	Shenehon's Ex. U1,	Shenehon's Ex. U1	882	Three Point Computations
	49	U5	to U5		
	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	St. Clair Discharge Curve
3130	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	St. Clair Discharge Curve
3137	49-55	Ex. 1, 2, 3, 4	U. S. Ex. 1, 2, 3, 4	7-10	Discharge Curves
	759	Shenehon's Ex. R	Shenehon's Ex. R	933	Red and blue
3140	759	Shenehon's Ex. R	Shenehon's Ex. R	933	Red and blue
3141	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	St. Clair Curve
	725-27	Shenehon's Ex. B-D	Shenehon's Ex. B and D		
3142	733	Shenehon's Ex. E, F, G, H	Shenehon's Ex. E, F, G, H		
	725-27	Ex. B and D	Shenehon's Ex. B and D		
3147	53	Govts. Ex. No. 3	U. S. Ex. No. 3	10	
	763	Shenehon's Ex. T	Shenehon's Ex. T	1207	
3153	745	Shenehon's Ex. K, L, M, N	Shenehon's Ex. K, L, M, N	948	Three Curve Series
3155	589	Groat's paper	Freeman's Ex. 4	1183	Discharge by Sus. Bridge and Whirlpool Gages
3156	733	Shenehon's Ex. E, F, G, H	Shenehon's Ex. E, F, G, H	2806, 3086	
3157	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	St. Clair Curve
3157	759	Shenehon's Ex. R	Shenehon's Ex. R	933	Red and blue
3174	721	Moore's Ex. 5	Moore's Ex. 5	2884	Printed in Record, page 2889
3184	51	U. S. Ex. No. 2	U. S. Ex. No. 2	10	St. Lawrence Curve Curve
3184	49-55	"Ex. 1, 2, 3, 4"	U. S. Ex. 1, 2, 3, 4	7-10	

Page of printed record	Page of folio of exhibits	Description used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
3190	739	Shenehon's Ex. H	Shenehon's Ex. H	2809	Fluctuations Niagara
3191	733	Shenehon's Ex. E, F, G	Shenehon's Ex. E, F, G	2806-3086	Discharge Curves Niagara
3192	733	Shenehon's Ex. E	Shenehon's Ex. E	3086	
3199	51	U. S. Ex. No. 2	U. S. Ex. No. 2	10	St. Lawrence Curve
3200	51	U. S. Ex. No. 2	U. S. Ex. No. 2	10	St. Lawrence Curve
3215	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3216	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3217	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3221	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3240	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3240	725-29	Shenehon's Ex. B and D	Shenehon's Ex. B and D		
3254	51	U. S. Ex. No. 2	U. S. Ex. No. 2	10	St. Lawrence Curves Niagara Curves
3274	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3275	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3325	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	
3326	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	
3327	49	U. S. Ex. No. 1	U. S. Ex. No. 1	7	
3329	759	"The red and blue"	Shenehon's Ex. R	933	
3335	49	Ex. No. 1	U. S. Ex. No. 1	7	
3350	771	Shenehon's Ex. V	Shenehon's Ex. V, May 18, 1914	3350	Lake Erie and Chippawa
3351	771	Shenehon's Ex. V	Shenehon's Ex. V	3350	
3354		"This Chart"	Shenehon's Ex. V	3350	
3359	731	Shenehon's Ex. D1	Shenehon's Ex. D1, May 18, 1914	3339	Open Section—Williams' Selections
	729	Shenehon's Ex. D	Shenehon's Ex. D	3087	Open Section—Niagara
3366	771	Shenehon's Ex. V	Shenehon's Ex. V	3350	Erie and Chippawa
3366	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3367	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3368	745	Three Curve Series	Shenehon's Ex. K, L, M, N	948	
3370	53	U. S. Ex. No. 3	U. S. Ex. No. 3	10	

Page of printed record	Page of folio of exhibits	Desciption used in text of testimony	Description used in folio of exhibits	Page introduced	Remarks
3463	792	Wisner's Chart 34-A	Wisner's Ex. 14F, June 16, 1914	3463	
3464	792	Wisner's Ex. 14G	Wisner's Ex. 14F	3463	Chart 34A—Canal Tests
3467	792	"Chart 14C"	Wisner's Ex. 14F	3463	Chart 34A—Canal Tests
3469	792	"Chart 14C"	Wisner's Ex. 14F	3463	Chart 34A—Canal Tests

EXHIBITS ATTACHED TO BILL OF COMPLAINT OF THE UNITED STATES NO. 115, EXHIBITS A TO G INCLUSIVE.

EXHIBIT "A."

"WHEREAS, by Section 10 of an act of Congress approved March 3, 1899, entitled 'An Act making appropriations for the construction, repair and preservation of certain public works, on rivers and harbors, and for other purposes,' it is provided that it shall not be lawful to alter or modify the course, location, condition or capacity of the channel of any navigable water of the United States unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same:

AND WHEREAS, The Sanitary District of Chicago, a municipal corporation, organized under the laws of the State of Illinois, has constructed an artificial channel from Robey street, Chicago, to Lockport, and has been heretofore granted permission by the Secretary of War to make certain improvements in the Chicago river for the purpose of correcting and regulating the cross section of the river so as to secure a flowage capacity of 300,000 cubic feet per minute with a velocity of one and one-quarter miles an hour, it being intended to connect the said artificial channel with the west fork of the south branch of Chicago river at Robey street in the said City of Chicago.

AND WHEREAS, The said Sanitary District of Chicago has now applied to the Secretary of War for permission to divert the waters of the said Chicago river and cause them to flow into the said artificial channel at Robey street as aforesaid;

AND WHEREAS, The said Sanitary District of Chicago represents that such movable dams and sluice gates as are necessary to, at all times, secure absolute and complete control of the volume and velocity of flow through the Chicago river have been constructed;

NOW THEREFORE, The Chief of Engineers having consented thereto, this is to certify that the Secretary of War hereby gives permission to the said Sanitary District of Chicago

to open the channel constructed and cause the water of Chicago river to flow into the same, subject to the following conditions:

1. That it be distinctly understood that it is the intention of the Secretary of War to submit the questions connected with the work of the Sanitary District of Chicago to Congress for consideration and final action, and that this permit shall be subject to such action as may be taken by Congress.

2. That if, at any time, it become apparent that the current created by such drainage works in the south and main branches of Chicago river, be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago river and its South Branch.

3. That the Sanitary District of Chicago must assume all responsibility for damages to property and navigation interests by reason of the introduction of a current in Chicago river.

Witness my hand this 8th day of May, 1899.

R. A. ALGER,
Secretary of War."

(WAR SEAL OFFICE)
JOHN M. WILSON,
Brig. Genl. Chf. of Engrs. U. S. A.

EXHIBIT "B".

"WHEREAS, under date of May 8th, 1899, the Secretary of War granted permission unto The Sanitary District of Chicago to open the artificial channel from Robey Street, Chicago, to Lockport, and cause the waters of Chicago river to flow into the same, upon the following condition, *inter alia:*

'2—That if, at any time, it becomes apparent that the current created by such drainage works in the south and Main branches of Chicago River be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago River and its south Branch.'

AND WHEREAS, It is alleged by various commercial and

navigation interests that the present discharge from the river into the Drainage Canal sometimes exceeds three hundred thousand (300,000) cubic feet per minute, causing a velocity of nearly three (3) miles per hour, which greatly endangers navigation, in the present condition of the river.

Now, THEREFORE, This is to certify that the Secretary of War, upon the recommendation of the Chief of Engineers, hereby directs said Sanitary District to regulate the discharge from the river into the Drainage Canal so that the maximum flow through the Chicago river and its south branch shall not exceed two hundred thousand (200,000) cubic feet per minute.

WITNESS my hand this ninth day of April, 1901.

ELIHU ROOT,
Secretary of War."

EXHIBIT "C".

"WAR DEPARTMENT,
WASHINGTON,

File No. 2560 of 1900.

July 23, 1901.

SIR:

Referring to War Department order of April 9th last, restricting the flow of water through the Chicago River under War Department permit of May 8, 1899 to 200,000 cubic feet per minute, and replying to your letter of the 15th instant, in which you request, for reasons stated, that the said order be amended to permit a flow of 300,000 cubic feet per minute between the hours of 4 P. M. and twelve o'clock midnight, I beg to inform you that I have this day approved the modification last referred to, which approval will be subject to revocation by the Department in case the increase shall prove to be dangerous to navigation.

Very respectively,

ELIHU ROOT,
Secretary of War.

Mr. Alexander J. Jones,
President, Sanitary District of Chicago,
Chicago, Illinois."

EXHIBIT "D".

"J. A. G. O.
(6353).

WHEREAS, Under date of May 8th, 1899, the Secretary of War granted permission unto the Sanitary District of Chicago to open the artificial channel from Robey Street, Chicago, to Lockport, and cause the waters of Chicago River to flow into the same, upon the following condition, *inter alia;*

"2.—That if, at any time, it becomes apparent that the current created by such drainage works in the South and Main Branches of Chicago River, be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago River and its South Branch";

AND WHEREAS, The Secretary of War subsequently directed said Sanitary District of Chicago, to regulate the discharge of water into the Chicago Drainage Canal so that the maximum flow through the Chicago River shall not exceed 200,000 cubic feet per minute from midnight to 4 p. m., nor 300,000 cubic feet per minute from 4 p. m. to midnight;

AND WHEREAS, Said Sanitary District of Chicago has applied to the Secretary of War for permission to increase the flow between midnight and 4 p. m. daily, to 250,000 cubic feet per minute; and the Chief of Engineers has recommended that the increase applied for be granted, but that the rate of flow from 4 p. m. to midnight be reduced to 250,000 cubic feet per minute, so that the flow through the Chicago River shall not exceed 250,000 cubic feet per minute throughout the 24 hours of the day.

NOW, THEREFORE, This is to certify that, in accordance with the recommendation of the Chief of Engineers, the Secretary of War hereby gives unto the said Sanitary District of Chicago permission to regulate said discharge so that the maximum flow through the Chicago River shall not exceed 250,000 cubic feet per minute throughout the 24 hours of the day, upon the following conditions:

1.—That this permission shall be in lieu of the present authorized rates of flow as stated above.

2.—That the permission herein given shall be subject to such modification as in the opinion of the Secretary of War the public interests may from time to time require.

3.—That said Sanitary District of Chicago shall be responsible for all damages inflicted upon navigation interests by reason of the increase in flow herein authorized.

WITNESS my hand this 5th day of December, 1901.

W. CARY SANGER,
Assistant Secretary of War."

EXHIBIT "E".

"J. A. G. O.
(6353)

WHEREAS, under date of December 5, 1901, by an instrument supplementary to the original permission granted by the Secretary of War, May 8, 1899, to the Sanitary District of Chicago to open the artificial channel from Robey Street, Chicago, to Lockport, and cause the waters of the Chicago River to flow into the same, the Secretary of War, pursuant to authority reserved in said permission of May 8, 1899, gave permission to the Sanitary District of Chicago to regulate said discharge so that the maximum flow per minute throughout the twenty-four hours of the day, upon the following conditions, *inter alia:*

"That the permission herein given shall be subject to such modification as in the opinion of the Secretary of War the public interests may from time to time require":

AND WHEREAS, The said Sanitary District of Chicago has applied for permission to increase the flow through the Chicago River from 250,000 cubic feet per minute to 350,000 cubic feet per minute during the closed season of navigation, in order to carry off the accumulations of sewage deposit which line the shores along the city;

NOW, THEREFORE, This is to certify that, in accordance with the recommendation of the Chief of Engineers, the Secretary of War hereby gives unto said Sanitary District of Chicago permission to increase the flow through the Chicago River from 250,000 cubic feet per minute to 350,000 cubic feet per minute, until the 31st day of March, 1903, after which date it shall be reduced to 250,000 cubic feet per minute, as now authorized, upon the following conditions:

1.—That the permission herein given shall be subject to such modification as in the opinion of the Secretary of War the public interests may from time to time require.

2.—That said Sanitary District of Chicago shall be respon-

sible for all damages inflicted upon navigation interests by reason of the increase in flow herein authorized.

WITNESS my hand this seventeenth day of January, 1903.

W. CARY SANGER,
Assistant Secretary of War."

EXHIBIT "F".

"THE SANITARY DISTRICT
OF CHICAGO.
Chicago, February 5th, 1912.

SIR:—

On behalf of the Board of Trustees of The Sanitary District of Chicago, I have the honor to apply for enlargement of the terms of an instrument executed by The Secretary of War May 8, 1899, as modified by instruments similarly executed on December 5, 1901, and June 30, 1910, respectively, in the following particulars and in view of the facts hereinafter set forth, to wit:

The flow of water from Lake Michigan through the canal of The Sanitary District of Chicago is now limited by the said instruments to 4167 cubic feet per second.

The population of the Sanitary District, the sewage of which is to be disposed of through the channels constructed and to be constructed by the said District, exceeds 2,500,000 persons, and is rapidly increasing. The only method at present available for disposing of the sewage of this population is by diluting the same with water withdrawn from Lake Michigan and flowing through the Chicago Drainage Canal. The least amount of water necessary to render sewage innocuous by the dilution method has been estimated by well recognized sanitary experts as 1,000 feet per second for every 300,000 inhabitants; so that the amount permitted to be withdrawn by the instruments to which reference has been made is much below the amount at present needed by the District.

The Sanitary District has been for some time engaged in investigating methods and devising plans for the treatment of the sewage with a view to requiring less water for its safe dilution in the future. The methods of other states and countries for such treatment of sewage, are not as yet entirely satisfactory to all concerned, and any changes of methods for large cities must necessarily require several years.

Until these experiments are concluded and proper works

installed, the use of additional water from Lake Michigan is essential to the health of the large population of the City of Chicago and of the Sanitary District and of those who live adjacent to the Des Plaines and Illinois rivers into which such waters are discharged.

Subject therefore to such restrictions as you may deem proper for the protection of the public interest, and to such a method of supervision as you may suggest to promote the general welfare, and pending the completion of the investigations now being conducted to render the use of increasing quantities of water in the future necessary; I have the honor to apply for permission for The Sanitary District of Chicago to withdraw from Lake Michigan through the Chicago river and Calumet river—not to exceed ten thousand cubic feet of water per second; such permission to be revocable at any time by The Secretary of War, and subject to such action as the Congress of the United States may see fit to take in the premises.

Respectfully submitted,

GEORGE M. WISNER,
Chief Engineer.

HON. HENRY L. STIMSON,
Secretary of War,
Washington, D. C."

EXHIBIT "G."

In the Matter of the Application of the Trustees of The Sanitary District of Chicago for Permission to Divert from Lake Michigan 10,000 *Cubic Feet of Water Per Second.*

WAR DEPARTMENT.

WASHINGTON, January 8, 1913.

The Sanitary District of Chicago applies to the War Department for permission to increase the amount of water it is authorized to withdraw from Lake Michigan from 4,167 cubic feet per second, the amount now authorized, to 10,000 cubic feet per second.

The Chicago Drainage Canal was opened in January, 1900. It reverses the flow of the Chicago River, which formerly emptied into Lake Michigan, and as a result a portion of the waters of that lake, instead of following their former course

through Lakes Huron, Erie and Ontario into the St. Lawrence, are now carried across the watershed into the Illinois River, and through that to the Mississippi and the Gulf of Mexico. The canal thus serves as a system of drainage for the City of Chicago, carrying the sewage of that city southward to the Mississippi, and thus protects the water supply of that city, which is taken from Lake Michigan.

Permission to divert water from Lake Michigan was first granted by my predecessor, Secretary Alger, on May 8, 1899. He permitted a flowage of 5,000 cubic feet per second, but his permit contained the following conditions:

1. That it be distinctly understood that it is the intention of the Secretary of War to submit the questions connected with the work of the Sanitary District of Chicago to Congress for consideration and final action, and that this permit shall be subject to such action as may be taken by Congress.

2. That if, at any time, it becomes apparent that the current created by such drainage works in the south and main branches of Chicago River be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago River and its south branch.

Subsequently, during the administration of Secretary Root, the amount of the current permitted to be taken was modified or restricted until December 5, 1901, when it was fixed at the amount now permitted, and these permits contained the condition—

that the permission herein given shall be subject to such modifications as in the opinion of the Secretary of War the public interests may from time to time require.

On March 14, 1907, an application made for permission to divert an additional 4,000 cubic feet per second for the purpose of reversing the current of the Calumet River and flowing that river also through the canal to drain the southern portion of Chicago was denied by Secretary Taft in an opinion in which he referred once more to the desirability of submitting "this question of capital and national importance to the Congress of the United States."

It is clear that even under the conditions heretofore manifested on these applications, the proposition to divert the waters of Lake Michigan into another watershed has not been entertained without hesitation and careful restriction by my predecessors. The propriety of obtaining congressional sanction for the project has been pointed out from the beginning; and the form in which the permit has been granted, even for the moderate amount of diversion permitted, has been so phrased as to indicate that the permission was predicated upon the absence of any substantial injury to commerce.

The sanitary canal has never received the direct sanction of Congress. It was built solely under the authority of the State of Illinois, as given in its 1889 general act for creating sanitary districts. And although pursuant to the suggestion of my predecessors the question of the propriety of its diversion of water from Lake Michigan was presented urgently in the reports of the Chief of Engineers for the years 1899 and 1900 as transmitted to Congress, no action upon the question has ever been taken by that body. In the argument before me it was urged that the present canal represented the growth and development of a national policy expressed in two acts of Congress, 1822 and 1827, which authorized the construction of a canal "to connect the Illinois River with Lake Michigan," thus connecting the two watersheds. (Acts of Mar. 30, 1822, and Mar. 2, 1827.) But these statutes authorized a canal for the purpose of navigation and not sanitation. (*Missouri* v. *Illinois,* 200 U. S., 526.) The Illinois and Michigan Canal, actually constructed under their authority, derived its water for navigation purposes from the Calumet, Des Plaines, and Chicago Rivers, and not from the Lakes. And although in the latter part of its existence it was used to a very slight extent to help purify the waters of the Chicago River and thus sanitate the City of Chicago, such a purpose could not have been dreamed of at the time its construction was authorized by Congress, 90 years ago. I can not see that its authorization and construction offer the slightest congressional sanction for the great canal now under discussion, which was not even contemplated until much more than half a century later. Even at the time when the present canal was constructed and opened it is very evident that its ultimate possible effect upon the navigation of the Great Lakes was not clearly realized by those interested in that navigation. The evidence before me indicates that the withdrawal of water from Lake Michigan at Chicago would require about five years to produce its full effect upon the levels of the Great Lakes (see report of International Waterways Commission on Chicago Drainage Canal, p. 7) and that this effect would be still further obscured by periodic oscillations in the lake levels. These facts may easily explain any inaction on the part of the Nation and their representatives to this withdrawal of water and make it clear that any argument of implied acquiescence must be scrutinized with unusual care.

In this respect the situation is now very different. The present application was opposed by representatives of 23

cities and 6 States interested in harbors and commerce upon the Great Lakes, notably the Cities of Duluth, Milwaukee, Toledo, Cleveland and Buffalo. It was opposed by representatives of the navigation interests engaged on the Chicago River as well as on the Great Lakes; and by the official representatives of the Canadian Government as well as private Canadian interests engaged in the navigation of the Lakes and the St. Lawrence River, including representatives of the Cities of Kingston and Montreal.

A very careful consideration of the voluminous evidence and statements submitted, as well as a consideration of the reports of other commissions and boards of engineers who have investigated the subject, leaves no doubt in my mind that the withdrawal of 10,000 cubic feet per second would substantially interfere with the navigable capacity of the Great Lakes and their connecting rivers. The Chief of Engineers, whose statutory authority in passing upon this application is concurrent with and independent of my own, and whose opinion upon such a question of scientific conclusion must be given especially weight, so states in his recommendation. His conclusions are corroborated by the authority of other boards of investigation, notably the report of the International Waterways Commission of January 4, 1907.

Careful observations and calculations conducted under the offices of the United States Lake Survey and reported through the Chief of Engineers, covering observations for the last 46 years, indicate that a withdrawal of 10,000 cubic feet per second would reduce levels at various places as follows:

	Inches.
Lakes Huron and Michigan	6.9
Lake St. Clair	6.3
Lake Erie	5.4
Lake Ontario	4.5
St. Lawrence River and Rapide Plat	4.8 plus.

The foregoing effects would be produced at mean lake levels; the lowering effects would be much greater at low-water periods—the precise time when any additional shortage would be most keenly felt. This reduction would create substantial injury in all of the American harbors of the Great Lakes and in the St. Marys, St. Clair and Detroit Rivers. It would produce equal injury in Canadian harbors on the Great Lakes, and a still greater injury on the lower St. Lawrence, the

Canadian officials claiming a probable lowering effect of 12 inches at Montreal at low water.

The United States has improved about 106 harbors and rivers on the Great Lakes affected by this diversion and has spent on such improvement over ninety millions of dollars. The Canadian Government has improved over 50 harbors on Georgian Bay and Lakes Huron, St. Clair, Erie and Ontario. By treaty, American vessels are accorded equal rights of navigation with Canadian vessels in all these waters, including the St. Lawrence River. The reduction of the water in these harbors and channels would diminish to just that extent the amounts of these improvements, and would nullify to just that extent the effects of the moneys which have been appropriated for that purpose by the respective Governments. Connecting various portions of these waterways are the two canals at the Sault Ste. Marie, the Welland Canal, and a number of canals on the St. Lawrence River. The available depth of water over one or all sills of each of these canals would be affected, and in some cases reconstruction might even be made necessary.

The enormous lake traffic which uses these harbors and these rivers is increasing with great rapidity, both in gross volume and in the size and average draft of the vessels employed therein. The Chief of Engineers reports that to lower the water surface 6 inches would reduce the permissible load of one of the large modern vessels by from 300 to 550 tons, with a consequent loss of from $3,600 to $7,500 in freights for such vessel per season. The International Waterways Commission reported that it would be a conservative estimate which would make the loss to the navigation interests resulting from a reduction of 6 inches in the depth of water as $1,500,000 per annum, or a sum which, capitalized at 4 per cent., would amount to a loss of $37,500,000 (see third progress report of International Waterways Commission of Dec. 1, 1907, p. 24). The lowest careful estimate of injury to American vessels alone is reported by the Chief of Engineers at $1,000,000 per year.

The argument was made before me that, owing to the well-known fact that the levels of the lake vary, owing to winds and change of barometric pressure, by amounts even greater than the reduction which would be caused by this canal, therefore the proposed reduction is of no consequence. This argument is well disposed of in the report of the International

Waterways Commission of January 4, 1907, on page 8, as follows:

It is evident that the average level of the lake may be lowered considerably without the change becoming immediately apparent, and that fact has been used as an argument to prove that the lowering caused by the Chicago Drainage Canal is of no consequence to those interested in navigation. Since they cannot see it they will not know it and will not feel it. The argument is fallacious. It is true that they cannot see it immediately, but they will soon feel it and will know it through the most costly means of acquiring knowledge—the injury to their material interests. The oscillations will remain the same as before, but low water will fall lower and high water will rise less high. The average draft of vessels must be diminished by the amount that the average level is lowered unless the depth be restored by remedial works.

In a word, every drop of water taken out of Chicago necessarily tends to nullify costly improvements made under direct authority of Congress throughout the Great Lakes, and a withdrawal of the amount now applied for would nullify such expenditures to the amount of many millions of dollars, as well as inflict an even greater loss upon the navigation interests using such waters.

On the other hand, the demand for the diversion of this water at Chicago is based solely upon the needs of that city for sanitation. There is involved in this case no issue of conflicting claims of navigation. The Chief of Engineers reports that so far as the interests of navigation alone are concerned, even if we should evenually construct a deep waterway from the Great Lakes to the Mississippi over the route of the sanitary canal, the maximum amount of water to be diverted from Lake Michigan need actually be not over 1,000 feet per second, or less than a quarter of the amount already being used for sanitary purposes in the canal. This estimate is confirmed by the report of the special board of engineers on the deep waterway from Lockport, Ill., to the mouth of the Illinois River, dated January 23, 1911. It is also confirmed by the practical experience of the great Manchester Ship Canal in England. From the standpoint of navigation alone in such a waterway too great a diversion of water would be a distinct injury rather than a benefit. It would increase the velocity of the current and increase the danger of overflow and damage to adjacent lands.

We have, therefore, presented in this case claims of entirely different characters and jurisdictions—the claim of sanitation on the one side and of navigation on the other; the vital interest of a single community on the one side and the broad interest of the commerce of the nation on the other. The discretion given to the Secretary of War under sections

9 and 10 of the act of 1899 is very broad, but I have very grave doubts as to whether it was intended to authorize him to grant a permit which would inflict a substantial injury upon commerce in order to benefit sanitation. The entire purpose and scope of that legislation was to make him the guardian of the commercial interests of the nation represented in their waterways. And while he sometimes under that statute must decide that the interests of one class of transportation are less important and must yield to the conflicting interests of another class, I have considerable doubt whether it was intended to give him authority to sacrifice substantial interests of navigation to entirely different claims over which he normally has no jurisdiction whatever.

But however that may be, and without resting my decision upon the question of my legal authority, I am quite clear as a matter of discretion that under the facts presented by this case no further diversion of water should be permitted at Chicago without the direct sanction of the Congress of the United States. I do not for one moment minimize the importance of preserving the health of the great City of Chicago; but when a method of doing this is proposed which will materially injure a most important class of the commerce of the nation and which will also seriously affect the interests of a foreign power, it should not be done without the deliberate consideration and authority of the representatives of the entire nation. The growth of Chicago is phenomenal and its representatives are quite unwilling to put any final limit to the demand which may be made upon the waters of Lake Michigan for its sanitation under the system now in use. I have before me the report of 1911 of the president of the sanitary district in which he says:

> I am of the opinion that the presumption that our water supply is to be limited to 10,000 cubic feet per second, or 600,000 cubic feet per minute, is gratuitous and mischievous and should not be voiced by the officials of this district. I believe that we should have the volume requisite to our needs as they appear and are justified.

It is therefore quite conceivable that compliance with their sanitary needs according to this method of sanitation may eventually materially change this great natural watercourse now existing through the Lakes. The weighing of the sanitation and possibly the health of one locality over against the commerce of the rest of the Nation and the consideration of our relations and obligations to Canada in respect to a great international waterway are not matters of mere technical or scientific deduction. They are broad questions of national

policy. They are quite different in character, for example, from the question of fixing the proper location of a pierhead line or the height or width of a drawbridge over a navigable stream—fair samples of the class of questions which come to the Secretary of War for decision under the above mentioned act of 1899. While the researches and opinions of experts in the respective fields are necessary and useful as an assistance toward reaching a fair and proper policy, the final determination of that policy should belong not to an administrative officer but rather to those bodies to whom we are accustomed to entrust the making of our laws and treaties.

In my view of the proper exercise of my discretion in this matter the foregoing considerations are sufficient for a decision of this case. Having reached the conclusion that the proposed diversion of the waters of Lake Michigan would substantially injure the interests of navigation on the Great Lakes which it is my legal duty to protect, it would clearly follow that the present application should be denied.

I have carefully examined, however, the evidence which both sides have introduced bearing upon the sanitary needs of the City of Chicago, and my conclusion is in no way shaken. I am not persuaded that the amount of water applied for is necessary to a proper sanitation of the City of Chicago. The evidence indicates that at bottom the issue comes down to the question of cost. Other adequate systems of sewage disposal are possible and are in use throughout the world. The problem that confronts Chicago is not different in kind but simply larger and more pressing than that which confronts all of the other cities on the Great Lakes, in which nearly 3,000,000 people of this country are living. The urban population of those cities, like that of Chicago, is rapidly increasing, and a method of disposition of their sewage which will not injure the potable character of the water of the Lakes must sooner or later be found for them all. The evidence before me satisfies me that it would be possible in one of several ways to at least so purify the sewage of Chicago as to require very much less water for its dilution than is now required by it in its unpurified condition. A recent report of the engineer of the sanitary commission (Oct. 12, 1911) proposes eventually to use some such method, but proposes to postpone its installation for a number of years to come, relying upon the present more wasteful method in the meanwhile. It is manifest that so long as the city is permitted to increase the amount of water which it may take from

the Lakes, there will be a very strong temptation placed upon it to postpone a more scientific and possibly more expensive method of disposing of its sewage. This is particularly true in view of the fact that by so doing it may still further diminish its expenses by utilizing the water diverted from the Lakes for water power at Lockport. But it must be remembered that for every unit of horsepower realized by this water at Lockport four units of similar horsepower would be produced at Niagara, where the natural conditions are so much more favorable. Without, therefore, going more into detail in a discussion of this question, I feel clear that no such case of necessity has been presented by the evidence before me as would justify the proposed injury to the many varied interests in the great waterways of our lakes and their appurtenant rivers.

It remains only to consider certain special arguments that have been pressed upon me. It has been urged that the levels of the lakes, even if lowered, could be restored by compensating works. To a certain extent that is true. But the very nature of this consideration offers another illustration of the importance of having the whole question passed upon by Congress. Such compensating works can only be constructed by the authority of Congress and at very considerable cost. It is not a matter which is in the hands of the Secretary of War. Permission to divert water which will at one and the same time nullify the effect of past appropriations and make necessary similar expenditures in the future, should be granted only with the express consent of the body in whose hands the making of such appropriations and the authorization of such works rest.

Furthermore, in most cases such compensating works could only be constructed with the joint consent of our neighbor Canada. The United States Government alone would be unable, even if it were willing to spend its own funds, to compensate for the damage done through the lowering of these levels, unless Canada were willing to join in constructing the portion of such works which would necessarily stand upon Canadian soil.

The question therefore becomes not merely national but international, and this leads me to the consideration of the arguments which were urged by both sides in reference to the treaty with Great Britain in respect to Canada of January 11, 1909. A careful consideration of that treaty fails to indicate to me that it is in any way controlling upon the

questions now before me. It gives to the citizens of both countries certain mutual rights of navigation in the waters of the Great Lakes and their connecting rivers; but beyond that the question of the right to this diversion at Chicago seems to me to have been carefully excluded. The applicants for the permit have urged upon me that article 8 of the treaty gives a preference to the uses of water of the lakes for domestic and sanitary purposes over the uses of such water for navigation. Article 8, however, applies only to future cases brought before the International Joint Commission; and furthermore I am clearly of the opinion that the domestic and sanitary purposes referred to in that article were intended to be the "ordinary" uses of such waters for domestic and sanitary purposes referred to in article 3. It would be quite contrary to our own national policy to give such a preference to an extraordinary sanitary use of such a character as to create a substantial injury to navigation. The matter has been before our own Supreme Court in the case *of the United States* v. *the Rio Grande Dam & Irrigation Co.* (174 U. S., 690). In that case the Supreme Court held that a company which proposed to take the water of the Rio Grande river for the purpose, among others, "of supplying water to cities and towns for domestic and municipal purposes" could be prevented from so doing when the result would be a substantial injury to the navigability of the Rio Grande river farther down. In its opinion the court said:

> The question always is one of fact, whether such appropriation substantially interferes with the navigable capacity within the limits where navigation is a recognized fact. In the course of the argument, this suggestion was made, and it seems to us not unworthy of note, as illustrating this thought. The Hudson river runs within the limits of the State of New York. It is a navigable stream and a part of the navigable waters of the United States, so far at least as from Albany southward. One of the streams which flows into it and contributes to the volume of its waters is the Croton river, a non-navigable stream. Its waters are taken by the State of New York for domestic uses in the City of New York. Unquestionably the State of New York has a right to appropriate its waters, and the United States may not question such appropriation, unless thereby the navigability of the Hudson be disturbed. On the other hand, if the State of New York should, even at a place above the limits of navigability, by appropriation for any domestic purposes, diminish the volume of waters, which, flowing into the Hudson, make it a navigable stream, to such an extent as to destroy its navigability, undoubtedly the jurisdiction of the National Government would arise and its power to restrain such appropriation be unquestioned; and within the purview of this section (act of Sept. 19, 1890, ch. 907) it would become the right of the Attorney General to institute proceedings to restrain such appropriation.

The treaty, however, contains provisions in its article 10 by which "any questions or matters of difference arising between the high contracting parties involving the rights, obli-

gations, or interests of the United States or of the Dominion of Canada, either in relation to each other or to their respective inhabitants, may be referred for decision" to an international joint commission established by the said treaty. The hearing before me brought forth the fact that the Government of Canada regards the proposal contained in this application as one which effects the material interests of that country. The establishment by formal treaty between the two countries of a tribunal with jurisdiction to decide just such questions seems to me to afford an additional reason against the assumption of jurisdiction to decide the question by an administrative officer of one of those countries.

In short, after a careful consideration of all the facts presented, I have reached the following conclusions:

First. That the diversion of 10,000 cubic feet per second from Lake Michigan, as applied for in this petition, would substantially interfere with the navigable capacity of the navigable waters in the Great Lakes and their connecting rivers.

Second. That that being so, it would not be appropriate for me, without express congressional sanction, to permit such a diversion, however clearly demanded by the local interests of the sanitation of Chicago.

Third. That on the facts here presented no such case of local permanent necessity is made evident.

Fourth. That the provisions of the Canadian treaty for a settlement by joint commission of "questions or matters of difference" between the United States and Canada offer a further reason why no administrative officer should authorize a further diversion of water, manifestly so injurious to Canada, against Canadian protest.

The prayer of the petition is therefore denied.

HENRY L. STIMSON,
Secretary of War.

EXHIBITS ATTACHED TO THE ANSWER OF THE SANITARY DISTRICT OF CHICAGO.

EXHIBITS A TO M INCLUSIVE.

(Exhibit A is a copy of Act of May 29, 1889, creating the Sanitary District and amendments thereto.)

Exhibits Attached to Answer.

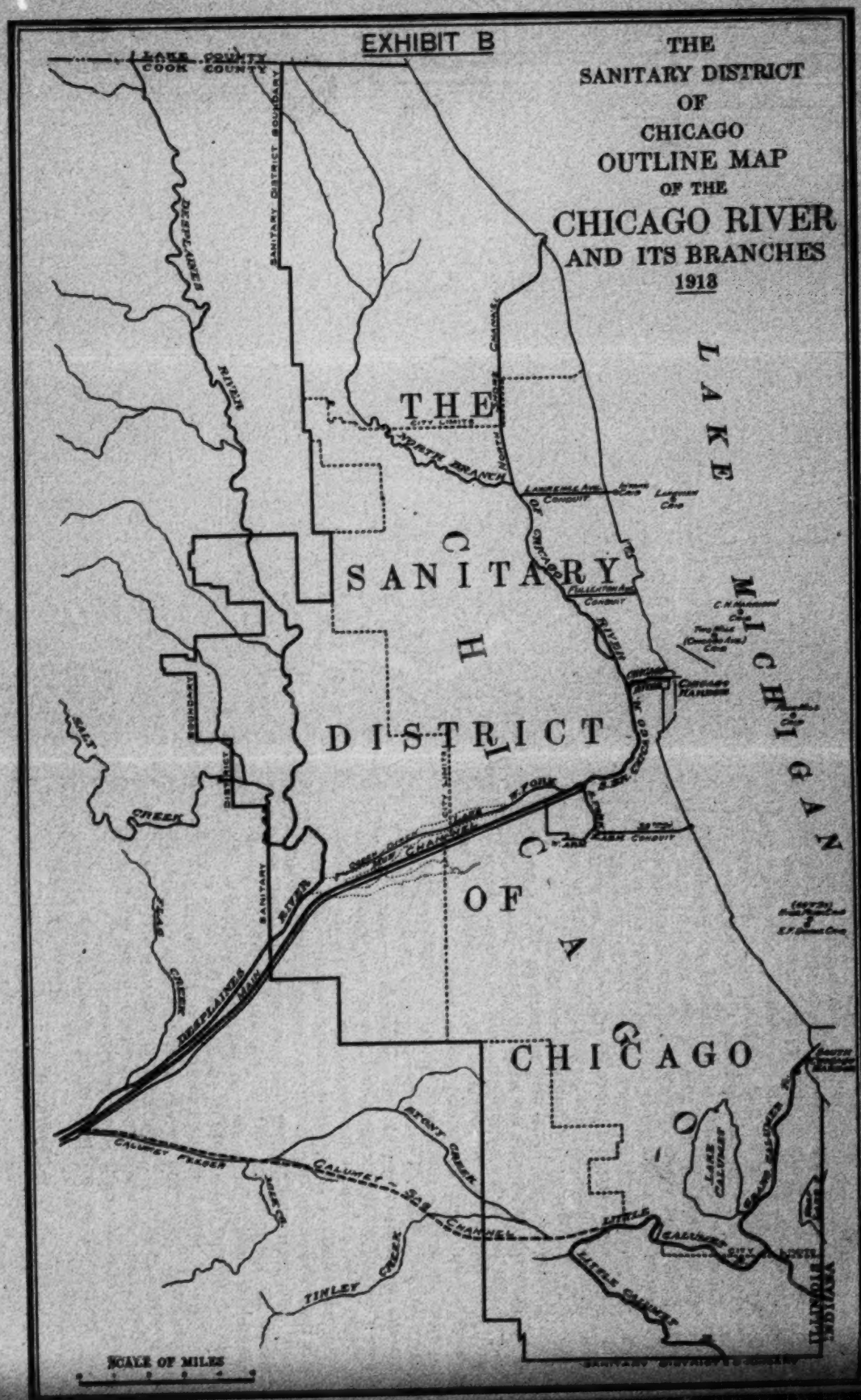


EXHIBIT "C"

War Department
Washington,

March 14, 1907.

In the matter of the application of the Sanitary District of Chicago to reverse the flow of the Calumet River.

This application is made under Section 10 of the act of March 3, 1899 (30 Stat. L., 1151), which provides as follows:

> "Sec. 10. That the creation of any obstruction, not affirmatively authorized by Congress, to the navigable capacity of any of the waters of the United States is hereby prohibited; and it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty or other structures in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill or in any manner to alter or modify the course, location, condition, or capacity of, any port, roadstead haven, harbor, canal, lake, harbor of refuge. or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same."

The application of the Sanitary District is for leave to reverse the flow in the Calumet River in such a way as to make the water to flow out of the lake instead of to flow into it and to discharge the water from the Calumet River into the Drainage Canal. The Chief of Engineers was at first of opinion that such a change in the flow of the river, it was not within the power of the Chief of Engineers to recommend, or within the power of the Secretary of War to permit. This expression of opinion as to the construction of the statute was submitted to the Judge Advocate General, who holds that Section 10, as quoted above, applies to this case and that it is one in which work could be allowed under the recommendation of the Chief of Engineers and the permission of the Secretary of War. Upon the construction of the Judge Advocate General I requested the Chief of Engineers to make his recommendation, which he has done as follows:

February 23, 1907.

1. Respectfully returned to the Secretary of War.

2. The subject of the abstraction of water from Lake Michigan has been elaborately investigated by the Lake Survey Office at Detroit, and the results are published in the annual reports of the Chief of Engineers for the years 1900, 1902 and 1904. The international Waterways Commission has also given it careful consideration, and its conclusions are set forth in report of January 4, 1907, printed as War Department Document No. 293.

3. In my opinion, this abstraction will undoubtedly lower the levels of all the waters of the Great Lakes, except those of Lake Superior, and thus diminish the navigable capacity and depth of the various channels and harbors which have been deepened and improved under authority of Congress.

4. Leaving out Lake Superior, there are more than 100 works of river and harbor improvements on the Great Lakes and their connecting waters, for which appropriations aggregating more than $80,000,000 have been made. The application of this vast sum has resulted in securing and maintaining specified depths and widths of channel, which Congress has decided to be required for the accommodation of the traffic using those waters.

5. To diminish these depths, even to a slight extent, would not only prove a serious injury to the traffic, but would practically undo the work which has been accomplished by Congressional direction, and necessitate the expenditure of further large sums of money for restoration. Any project that tends, in a measure, to annul or reverse the orders of Congress, as expressed in the various river and harbor acts appropriating funds for improving the harbors and channels connecting with the Great Lakes, should meet the disfavor of the Department, unless it has been sanctioned by that body. In my judgment, such a project is the one under consideration, and for this reason I am unwilling to recommend favorable action thereon, assuming that the Department is empowered to take such action, as is held by the Judge Advocate General.

A. MACKENZIE,
Brig. Gen., Chief of Engineers, U. S. Army."

It is quite evident from the reading of the statute that Congress intended in this statute, as in many others, to give the

Chief of Engineers authority, independent of the Secretary of War, in reaching a conclusion as to the wisdom and propriety of granting a permit under the section, and that unless the Chief of Engineers shall recommend the granting of the permit, the Secretary of War is without power to give the requested authority. It follows, therefore, that the application must be denied whatever my view of the case.

The decision of the Chief of Engineers and its final character has made it unnecessary for me to consider the merits of the question, but I may say this much, that the application for a change in the Calumet River is to be made the basis for the withdrawal of a large amount of water from Lake Michigan and that all interested in the enormous lake traffic view the settlement of the question with grave apprehension. Added to this, is the international complication which is likely to arise in the threatened lowering of the lake level in the ports and harbors and canals of Canada. On the other hand, it is maintained with great emphasis and elaboration of detail that the change in the Calumet River, is essential to the healthful sanitation of Chicago, and that the threatened injury to navigation is so small as to be negligible.

Between two such great interests, the decision must be affected more or less by large public policy and expediency, and while I agree in the construction of the Judge Advocate General that the issue is left by statutes to the recommendation of the Chief of Engineers and the concurrent decision of the Secretary of War, it may be fortunate that circumstances now require submission of this question of capital and national importance to the Congress of the United States.

WM. H. TAFT,
Secretary of War.

(Reprinted from proceedings of Board of Trustees, March 27, 1907, pages 211-12.)

EXHIBIT "D."

"WAR DEPARTMENT
WASHINGTON, September 11, 1907.

SIR:

Referring to your letter of 2nd instant, in which you request approval of proposed drainage channel to connect Lake Michigan at Wilmette, Ill., with the North Branch of the Chicago River; also permission to construct a pile crib in Lake Michigan at mouth of same, and to deposit filling within the limits of such crib, I beg to inform you that the War Department will interpose no objection to the project as set forth in your letter and indicated on drawing submitted, provided the following conditions are complied with:

1. That the pier constructions, the filling behind the same, and the excavation of the proposed channel shall be done subject to the supervision and approval of the local officer of the Corps of Engineers, U. S. Army, at Chicago, so far as to see that the work authorized is not exceeded;

2. That the total diversion of water from Lake Michigan through the Chicago River into the Illinois River shall be no greater than already authorized by past War department permits;

3. That the work shall be commenced before December 31, 1908, and completed within five years thereafter.

Very respectfully,

ROBERT SHAW OLIVER,
Acting Secretary of War

G. M. Wisner, Esq.,
Chief Engineer, The
Sanitary District of Chicago
American Trust Building,
Chicago, Illinois."

EXHIBIT E.

Permit

WAR DEPARTMENT, WASHINGTON,
June 30, 1910.

SIR:

Referring to your application of the 27th instant on behalf of the Board of Trustees of The Sanitary District of Chicago to open a channel from the Calumet River to its existing Main Channel so as to substitute two routes instead of one between Lake Michigan and its canal, I have the honor to advise you to the following effect:

It appears from the records of the Department that by an instrument executed May 8, 1899, The Sanitary District of Chicago was given permission to connect its Drainage Canal with the South Branch of the Chicago River at Robey Street, in the City of Chicago, and to divert the waters of Lake Michigan through the Chicago River into said canal, subject to certain specified conditions designed to limit the amount of such diversion and in other ways to protect the public interest. The permission so granted was subsequently modified at various times, and by an instrument executed December 5, 1901, the amount of flow was fixed at not exceeding 250,000 cubic feet per minute, equivalent to 4,167 cubic feet per second, which is the present rate allowed. At the time the original permit was given a connection with the Calumet River was not mentioned but if it had been it is probable that a connection with that river as well as with the Chicago River would have been allowed.

So long as the water-flow remains unchanged there seems to be no special objections to its extension to both rivers instead of confining it to a single one, especially since if the new (Calumet) route be developed later to a navigable state the double route will be advantageous to navigation interests. Accordingly, in view of the favorable recommendation of the Chief of Engineers and of the consent thereto by the Attorney General, under the condition hereinafter prescribed, the Department hereby modifies the existing permission so as to allow the division of the already permitted water-flow in such manner as to reach the Sanitary District Canal by way of the Calumet River and a connecting channel, as well as by way of its present route through the Chicago River, subject to all pertinent conditions of the existing permissions and to other express conditions, as follows:

(a) That it be distinctly understood that it is the intention of the Secretary of War to submit the questions connected with the work of The Sanitary District of Chicago to Congress for consideration and final action, and that this permit shall be subject to such action as may be taken by Congress.

(b) That if at any time it become apparent that the current created by such drainage work in the Calumet, as well as Chicago rivers, be unreasonably obstructive to navigation, or injurious to property, the Secretary of War reserves the right to close the discharge through said channel or rivers, or to modify it to such an extent as may be demanded by navigation and property interests along said rivers.

(c) That The Sanitary District of Chicago must assume all responsibility for damages to property and navigation interests by reason of the introduction of a current in the Calumet as well as Chicago river.

(d) That the amount of water withdrawn from Lake Michigan, through the Chicago and Calumet rivers together, shall not exceed the total amount of 250,000 cubic feet per minute (4,167 cubic feet per second) already authorized to be withdrawn through the Chicago River alone.

(e) That the permission herein given shall be subject to such modification as in the opinion of the Secretary of War the public interests may from time to time require.

(f) That this permission shall in nowise affect or in any manner be used in the friendly suit now pending in the Circuit Court of the United States for the Northern District of Illinois brought by the United States of America against the Sanitary District of Chicago, to determine the right of the said Sanitary District to divert from Lake Michigan for sanitary purposes an amount of water in excess of that now being diverted, without having first obtained a permit from the Secretary of War.

(g) That the War Department shall have free access at all times to the waterflow records of The Sanitary District of Chicago and free access also to the regulating works and all other parts of its canals for the purpose of checking records or making water-flow measurements.

(h) That the plans for the proposed work shall be submitted to and approved by the Chief of Engineers and the Secretary of War.

(i) That the work shall be subject to the supervision and

approval of the Engineers Officer of the United States Army in charge of the locality.

Very respectfully,

ROBERT SHAW OLIVER,
Acting Secretary of War.

Mr. George M. Wisner,
Chief Engineer, Sanitary District of Chicago, Chicago, Ill.
(Reprinted from the proceedings of the Board of Trustees, November 2, 1911, pages 1323-25.)

EXHIBIT "F."

MEMORIAL TO CONGRESS ON THE SUBJECT OF THE ILLINOIS AND MICHIGAN CANAL.

(Laws Extra Session, 1826, p. 97.)

To the Honorable the Senate and House of Representatives of the United States of America in Congress assembled: The memorial of the General Assembly of the State of Illinois respectfully represents that the construction of a canal uniting the waters of Lake Michigan with the Illinois river, will form an important addition to the connecting links in the chain of internal navigation, which will effectually secure the indissoluble union of the confederate members of this great and powerful Republic. By the completion of this great and valuable work, the connection between the north and the south, the east and the west, would be strengthened by the ties of commercial intercourse and social neighborhood, and the union of the states might bid defiance to internal commotion, sectional jealousy and foreign invasion. All the states of the Union would then feel the most powerful motives to resist every attempt at dissolution. To effect so great and desirable an object, your memorialists believe to be of sufficient importance to engage the attention and awaken the munificient patronage of a government whose principle of action is the promotion of the general welfare. Your memorialists are sensibly alive to the spirit of improvement that manifests itself in almost every section of our extensive country, and would fain lend a helping hand in so great and good a cause; their situation, however, forbids their doing much, without the aid of the federal government; into whose treasury almost all the funds whether brought hither by emigrants or earned by the industry of their citizens, are

paid for the purchase of the public lands. While this state of things shall continue and the money thus paid into the treasury of the Union is taken out of our State, our people will not be able to engage in the glorious work of improving our common country. Ought the people of this State to stand by with folded arms and behold the great work of internal improvement progress in other states without making an effort to improve their own conditions, and at the same time advance the interest of our beloved country? A condition thus paralyzed, is at war, not only with our interests, but with the best feelings of our hearts. Did this State possess the public domain lying within its bounds, as in the case with the older members of this confederacy, your memorialists would not appear before your honorable body to solicit aid in this important work. If, as your memorialists believe, the construction of this canal would be highly beneficial to the Union at large; if the receipts into the treasury of the United States would be augmented by the increased sales of public lands; and if the interest of this State would be also advanced thereby; is it unreasonable to apply to a paternal government for assistance in the promotion of such beneficial ends? It is unnecessary for your memorialists to enlarge on the great advantages of this canal to the Union, in the facilities to be afforded in the event of a war with either the Indian tribes inhabiting our frontier, or the British nation. Your honorable body is aware that this State is situated on the borders of an Indian country, filled with numerous and powerful tribes of the sons of the forest. If our country should be again engaged in war, the saving of expense in the transportation of munitions of war, would alone defray the expense of the contemplated canal, and justify the United States in making a liberal appropriation for its construction. Your memorialists do not, however, ask your honorable body to appropriate money out of the treasury to aid them in this work; they only ask for a tract of land, through which the contemplated canal may pass, and which, for a series of years, will be wholly unproductive to the government unless the canal shall be commenced under auspices favorable to its completion; in which event all the land in the vicinity would immediately become available to the United States. Your memorialists sincerely believe that a liberal appropriation of land for this object, would, even in a pecuniary point of view be of immense importance to the treasury of the Union. The public lands in the vicinity would not only sell, but at a considerable advance upon the minimum price. Should this

opinion be correct (and does not experience justify it?) the United States would be gainers by the proposed donation to the State. Your memorialists further state that at their last session, they passed an act of incorporation, upon very liberal terms, authorizing a company to construct the projected canal; but the remoteness of the country from the residence of capitalists, has prevented them from engaging in the work. At their present session, your memorialists have repealed the charter; and their only hope of soon beginning the work depends upon the liberality of your honorable body. Your memorialists have caused the route to be explored and estimates to be made of the probable expense of the work; from which it appears that the cost of constructing the canal will not be less than $600,000 and may possibly amount to $700,000. To the end, therefore, that your memorialists may be enabled to commence and complete this great and useful work, we pray your honorable body to grant to this State the respective townships of land through which the contemplated canal may pass; the avails of which, to be appropriated exclusively, to the construction of said canal, upon such terms and conditions as to your honorable body may seem proper.

EXHIBIT "G."

"An Ordinance for Cleansing the Chicago River and Appropriating the Proceeds of Two Hundred and Fifty Bonds Therefor.

SECTION 1. Be it ordained by the Common Council of the City of Chicago (June 5, 1865), That the plan of the board of public works for cleansing the Chicago River and its branches by cutting down the summit of the Illinois and Michigan Canal below the level of Lake Michigan so as to draw from it at a low stage of water in the lake not less than twenty-four thousand (24,000) cubic feet of water per minute, is hereby approved, and said board are hereby authorized to execute said work.

SECTION 2. That the board of public works are hereby authorized and empowered for the purpose of prosecuting the work described in the previous section, to make any contract necessary to carry into effect such purpose with the trustees of the Illinois and Michigan Canal, in conformity with and subject to the general provisions of the city charter.

SECTION 3. That as a temporary expedient for cleansing the South Branch of the Chicago River, the said board are hereby authorized and empowered to contract with the said trustees for the pumping from the river

into the canal, by the hydraulic works at Bridgeport, and discharging through the canal of such amount of water as shall be found necessary and practicable for such purpose.

SECTION 4. That for the purpose of carrying out the improvement specified in the foregoing sections, the board of public works be and they are hereby authorized to issue 250 bonds of the denomination of $1,000 each, to be dated July 1, 1865, and payable in New York, twenty-five years after the date thereof, with coupons for interest, at the rate of seven per centum per annum, payable semi-annually in New York; the said bonds to be issued in conformity with the provisions of an act of the General Assembly of the State of Illinois, approved February 15, 1865, and entitled 'An act to amend an act entitled an act to reduce the charter of the City of Chicago, and the several acts amendatory thereof, into one act, and to revise the same,' approved February 13, 1863."

EXHIBIT H.

APPLICATION OF THE SANITARY DISTRICT FOR THE IMPROVEMENT OF THE CHICAGO RIVER.

CHICAGO, June 16, 1896.

To the Honorable Daniel S. Lamont,
Secretary of War,
Washington, D. C.

DEAR SIR:

The work of The Sanitary District of Chicago has progressed so far that it is now necessary for us to enter upon that which must be done in the Chicago River to make available the artificial channel which we have under construction from Robey Street, Chicago, to Lockport in Will County, twenty-eight miles distant.

Our connection with Lake Michigan must be through the Chicago river with the West Fork of the South Branch of which we make a junction at Robey Street. We send herewith a map showing in a general way our plans for improving the Chicago River by widening and deepening at the points indicated thereon by red hatchings and by figures which refer to explanation, given in the legend on the map. It is desired to so correct and regularize the cross section of the

river as to secure a flowage capacity of 300,000 cubic feet per minute with a velocity of one and one-quarter miles per hour. The cross section necessary to accomplish this can be obtained throughout the greater part of the distance between Monroe Street and Robey Street, by dredging the river to a depth of 20 ft. at mid stream, with 12 ft. at dock lines and a uniform slope away from docks of one foot in five, so that the full depth would be reached forty feet from the dock lines; but there are places so narrow that this cross section can only be obtained by widening the river; and again the depth to be obtained in the vicinity of Van Buren Street is limited by the height of the crown of the tunnel. To obviate this difficulty it is purposed to secure the requisite cross section by constructing a by-pass to the west of the bridges at Adams, Jackson and Van Buren Streets, as indicated. We ask your permission to proceed with the work upon the lines indicated and so far as is consistent with propriety the co-operation of the United States Engineering Department.

Awaiting your favorable reply, and holding ourselves ready to respond to any call from you for fuller information as to our plans, I am

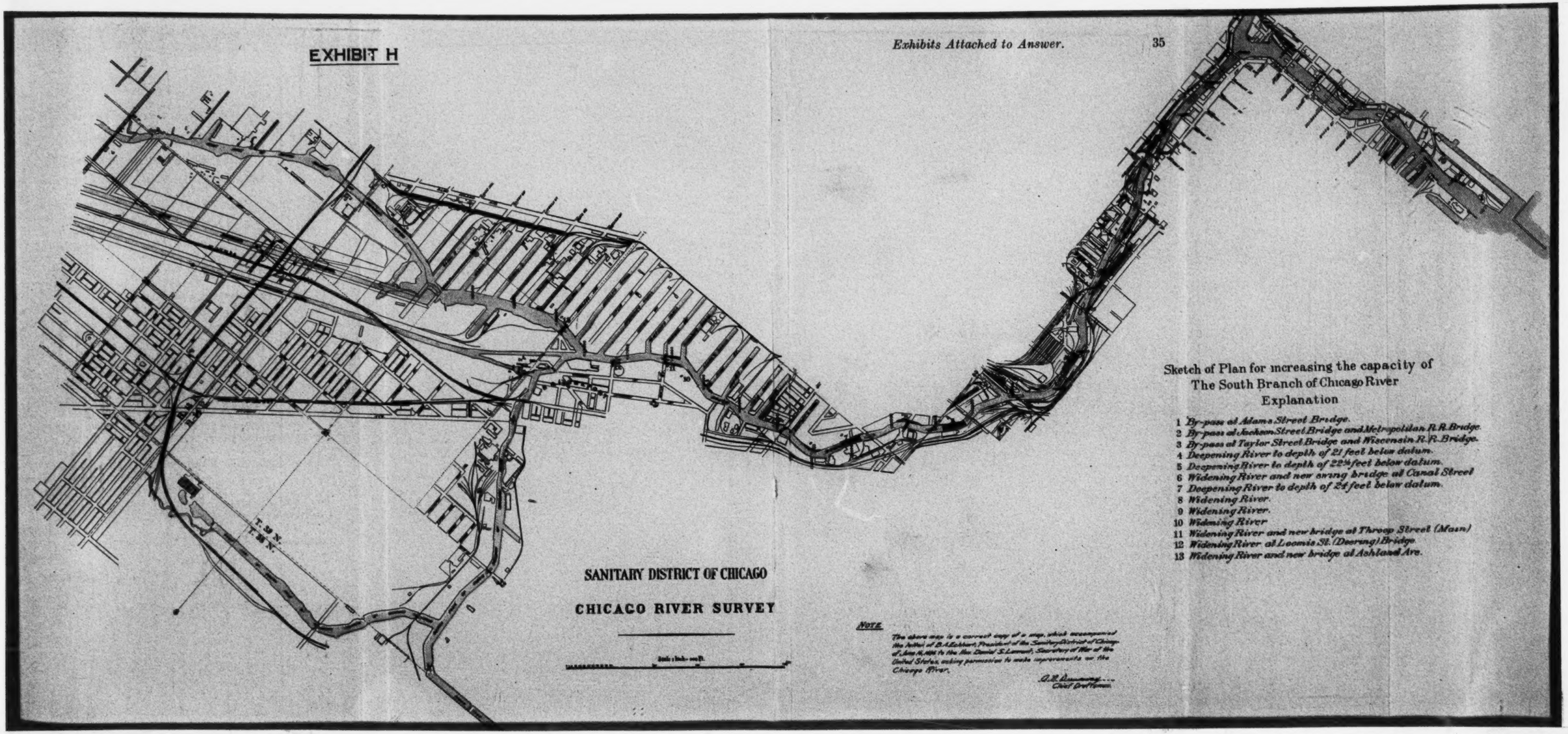
Yours respectfully,

(Signed) B. A. ECKHART,

President.

A copy of the above letter is found at Page 297 of the Clerk's Copy Letter Book "C," being letter book from September 20, 1895, to January 11, 1907.

EXHIBIT H



SANITARY DISTRICT OF CHICAGO

CHICAGO RIVER SURVEY

Scale 1 Inch = 200 Ft.

NOTE.

The above map is a correct copy of a map which accompanied the letter of B. A. Eckhart, President of the Sanitary District of Chicago of June 16, 1899 to the Hon. Daniel S. Lamont, Secretary of War of the United States, asking permission to make improvements on the Chicago River.

A. N. Rosenwald
Chief Draftsman

Sketch of Plan for increasing the capacity of
The South Branch of Chicago River
Explanation

1 By-pass at Adams Street Bridge.
2 By-pass at Jackson Street Bridge and Metropolitan R.R. Bridge.
3 By-pass at Taylor Street Bridge and Wisconsin R.R. Bridge.
4 Deepening River to depth of 21 feet below datum.
5 Deepening River to depth of 22½ feet below datum.
6 Widening River and new swing bridge at Canal Street
7 Deepening River to depth of 24 feet below datum.
8 Widening River.
9 Widening River.
10 Widening River
11 Widening River and new bridge at Throop Street (Main)
12 Widening River at Loomis St. (Deering) Bridge.
13 Widening River and new bridge at Ashland Ave.

EXHIBIT I.

PERMIT FOR THE IMPROVEMENT OF THE CHICAGO RIVER.

(Permit of July 3rd, 1896.)

Improvement of the Chicago river.

July 3, 1896.

SIR:

I have the honor to acknowledge the receipt of your letter of the 16th ultimo, requesting permission to make certain changes in the capacity of the channel of the Chicago River for drainage purposes at points indicated on the map accompanying the application, and in reply beg to say that upon investigation it is found that the permission requested can be granted upon the following conditions:

1. That while the general plan is approved, the Sanitary District of Chicago must furnish plans in triplicate on an enlarged scale showing each proposed new bridge, each by-pass and each new dock or wharf proposed to be built, in order that the Secretary of War may act intelligently in each case.
2. That this authority shall not be interpreted as approval of the plans of the Sanitary District of Chicago to introduce a current into Chicago River. This latter proposition must hereafter be submitted for consideration.
3. That it will not cover obstructions to navigation by reason of this work while in progress or when completed.
4. That the United States shall not be put to expense by reason of this work.
5. That this authority will expire by limitation in two years from date unless extended.

Very respectfully,

(Signed) JOSEPH B. DOE,
Acting Secretary of War.

B. A. Eckhart, Esq.,
President the Sanitary District of Chicago, Rialto Building, Chicago, Ill.

EXHIBIT J.

THE SANITARY DISTRICT OF CHICAGO.

Security Building.

CHICAGO, April 26, 1900.

To the Honorable
The Secretary of War.

SIR:

The Sanitary District of Chicago, a municipal corporation organized and existing under the laws of the State of Illinois, respectfully represents that, by the laws of the State of Illinois and the charter of this petitioner, it is authorized to enter upon, widen, deepen and otherwise improve any navigable stream, river or other water-way. That in pursuance of the power conferred upon it by the statutes of the State of Illinois, and in the performance of the duties enjoined upon it by the act of the Legislature authorizing its creation, and under which it is acting, it has been determined to improve the Chicago River by widening and deepening the same and to the end that such action on the part of your petitioner may be conformable to law and the statutes of the United States in that behalf, it hereby makes application for permission to make the changes, alterations and improvements in said Chicago River from or near Lake Street in the City of Chicago to or near Ashland Avenue in the City of Chicago, said work to conform to the plan and specifications as follows:

(a) A map herewith exhibits the existing boundaries of that part of the South Branch of the Chicago River which it purposes and desires to improve.

(b) The work to be done contemplates widening the river to a width of two hundred (200) feet between dock lines, except in so far as bridge abutments may project into the stream outside of the new dock lines; said widening in all cases to be made with a view of improving the navigability of the stream.

(c) The work to be so done as to ultimately permit excavation of the river bed to a depth of thirty (30) feet below water surface throughout the central portion of the stream.

(d) The widening of the river is to be so disposed that the effect will be to produce a straighter channel than now exists and, furthermore, to result in a continuous dock line having straighter alignment and being better disposed for navigation than the docks which now exist.

(e) The work to be done is to be prosecuted progressively as to time. The rate of progress being limited by the rapidity with which right of way may be acquired and the resources for the execution of the work to be made available. The modification and alteration of said river as above indicated will greatly benefit navigation in said river. Your petitioner, therefore, respectfully requests that the plan of improvement as above outlined be approved by you.

Awaiting as early a reply as practicable under the circumstances, your petitioner has the honor to be,

Very respectfully yours,

THE SANITARY DISTRICT OF CHICAGO,

By WILLIAM BOLDENWECK,

President.

Attest:

JOSEPH F. HAAS,

Clerk.

EXHIBIT J-i.

CHICAGO, June 7, 1900.

To the Honorable,
the Secretary of War.

SIR:—

Under date of April 26, 1900, the Sanitary District of Chicago had the honor to address a communication to you containing an outline of the proposed improvement of a portion of the South Branch of the Chicago River. Accompanying the letter was a map showing the location of the South Branch of the Chicago River, the bridges spanning said river and, also, the width of the stream along the entire course of the South Branch of the river. Since that date the Sanitary District of Chicago passed an ordinance for the improvement of the South Branch of the Chicago River from the south line of Twelfth Street to the east line of Ashland Avenue, so as to make said South Branch, between the lines aforesaid, of a uniform width of two hundred (200) feet; the work to be done so as to ultimately permit excavation of the river bed to a depth of thirty (30) feet below water surface throughout the central portion of said stream, in accordance with the plans adopted by the Board of Trustees of the Sanitary District of Chicago, a copy of which plans is hereto annexed. The ordinance referred to being marked Exhibit "A," with this

letter; and the maps showing the plans of the proposed improvement being marked Exhibit "B." The maps are in two sections, known respectively as No. 2 and No. 3.

The Sanitary District of Chicago is a municipal corporation, organized and existing under the laws of the State of Illinois and by the laws of said State and the charter of said Sanitary District, it is authorized to enter upon, deepen, widen and otherwise improve any navigable stream, river, or other water-way; and that in pursuance of the power conferred upon it by the statutes of the State of Illinois and in performance of the duties enjoined upon it by the act of the legislature authorizing its creation, and under which it is acting, it determined upon said plans outlined in the enclosed ordinance and further illustrated by the maps hereto annexed; and the said Sanitary District, in compliance with the Statutes of the United States, hereby makes application to you for permission to make the changes, alterations and improvements in said South Branch of the Chicago River, from the south line of Twelfth Street to the east line of Ashland Avenue.

Awaiting as early a reply as practicable under the circumstances, your petitioner has the honor to be,

Very respectfully yours,

THE SANITARY DISTRICT OF CHICAGO,

By WILLIAM BOLDENWECK,

President.

Attest:

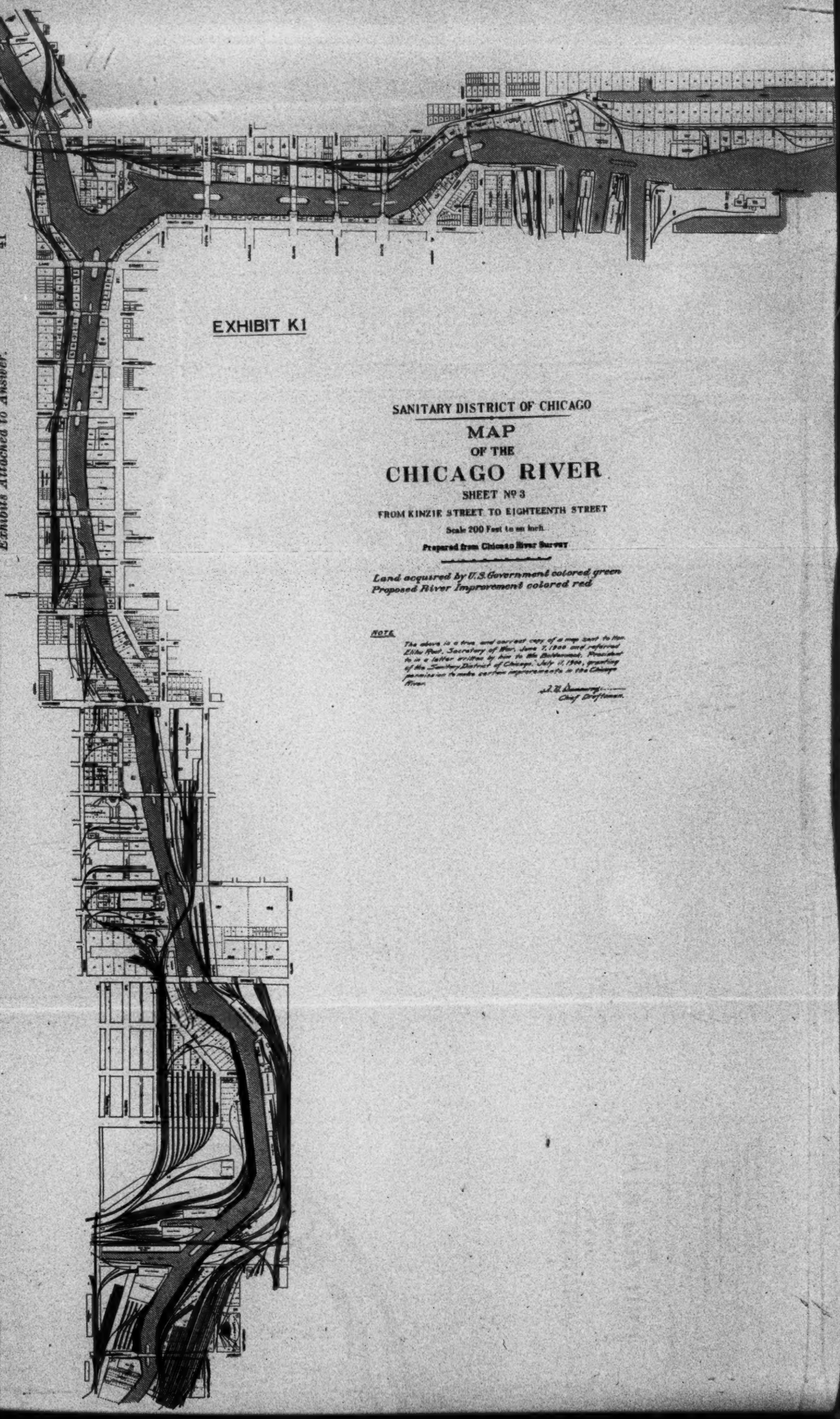
JOSEPH F. HAAS,

Clerk.

41

Exhibits Attached to Answer.

EXHIBIT K1



SANITARY DISTRICT OF CHICAGO

MAP
OF THE
CHICAGO RIVER

SHEET № 3

FROM KINZIE STREET TO EIGHTEENTH STREET

Scale 200 Feet to an Inch

Prepared from Chicago River Survey

Land acquired by U.S. Government colored green
Proposed River Improvement colored red

NOTE.

The above is a true and correct copy of a map sent to Hon. Elihu Root, Secretary of War, June 7, 1906 and referred to in a letter written by him to the Board of Trustees, President of the Sanitary District of Chicago, July 7, 1906, granting permission to make certain improvements in the Chicago River.

J. H. Dunnavan
Chief Draftsman.

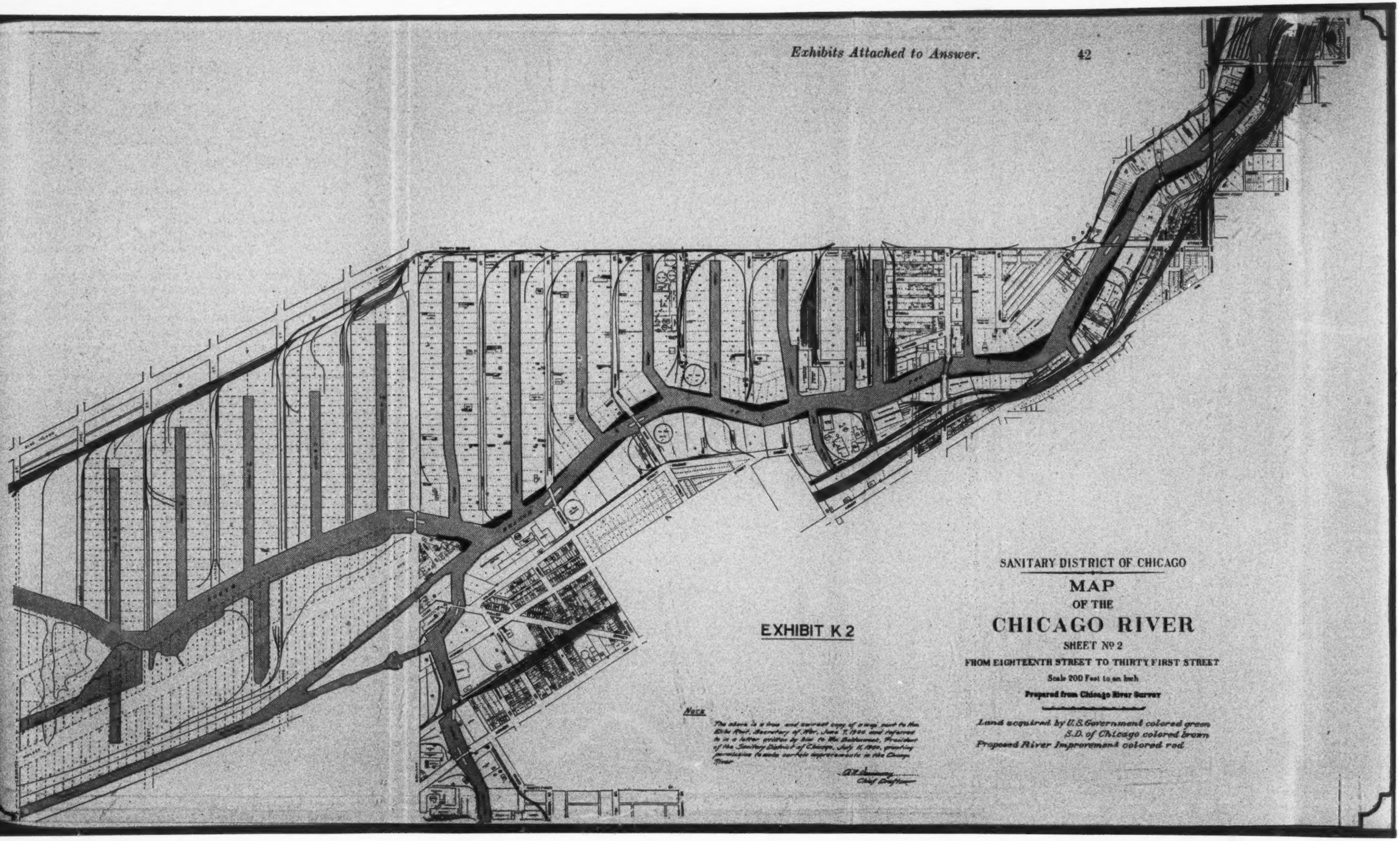


EXHIBIT K 2

SANITARY DISTRICT OF CHICAGO

MAP
OF THE
CHICAGO RIVER

SHEET Nº 2

FROM EIGHTEENTH STREET TO THIRTY FIRST STREET

Scale 200 Feet to an Inch

Prepared from Chicago River Survey

Land acquired by U.S. Government colored green
S.D. of Chicago colored brown
Proposed River Improvement colored red

NOTE

The above is a true and correct copy of a map sent to the Hon. Secretary of War, June 7, 1900 and referred to in a letter written by him to Mr. Bakewell, President of the Sanitary District of Chicago, July 11, 1900, granting permission to make certain improvements in the Chicago River.

Chief Engineer

EXHIBIT L.

War Department,

WASHINGTON, July 11, 1900.

SIR:

I have the honor to acknowledge the receipt of your letter of April 26th last, requesting, in behalf of the Sanitary District of Chicago, permission to change, alter and improve the Chicago River, from Lake Street to Ashland Avenue, in Chicago, as shown on maps which accompanied your said letter.

Replying thereto I beg to inform you that there is no objection on the part of the War Department to the prosecution of work of improvement of Chicago River, specified in the above mentioned letter and delineated on the maps which accompanied the same, it being understood that this statement as to the attitude of the War Department shall not be understood as involving the general government in any way with the expense incident to the carrying out of the project, and does not in any way invalidate, waive or affect the right of the Secretary of War to regulate or revoke the permit granted under date of May 8, 1899, to the Sanitary District of Chicago, to divert the waters of the Chicago River and cause them to flow into the artificial channel, such permission being subject to the following conditions, viz:

"1. That it be distinctly understood that it is the intention of the Secretary of War to submit the questions connected with the work of the Sanitary District of Chicago to Congress for consideration and final action and that this permit shall be subject to such action as may be taken by Congress.

"2. That if, at any time, it becomes apparent that the current created by such drainage works in the South and Main Branches of Chicago River, be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago River and its South Branch.

"3. That the Sanitary District of Chicago must assume all responsibility for damages to property and navi-

gation interests by reason of the introduction of a current in Chicago River.

Very respectfully,

ELIHU ROOT,
Secretary of War.

Mr. Wm. Boldenweck,
President the Sanitary District of Chicago,
Security Building, Chicago, Ill."

EXHIBIT L-1.

War Department,

WASHINGTON, July 11, 1900.

SIR:—

In response to your application of the 7th ultimo, for permission to make certain changes, alterations and improvements in the South Branch of the Chicago River, from the south line of Twelfth Street to the east line of Ashland Avenue, as shown on plans which accompanied said application, I beg to inform you that there is no objection on the part of the War Department to the prosecution of the work as specified, it being understood that this statement as to the attitude of the War Department shall not be understood as involving the general government in any way with the expense incident to the carrying out of the project, and does not in any way invalidate, waive or affect the right of the Secretary of War to regulate or revoke the permit granted, under date of May 8, 1899, to the Sanitary District of Chicago, to divert the waters of the Chicago River and cause them to flow into the artificial channel such permission being subject to the following conditions, viz:

"1. That it be distinctly understood that it is the intention of the Secretary of War to submit the question connected with the work of the Sanitary District of Chicago to Congress for consideration and final action, and that this permit shall be subject to such action as may be taken by Congress.

"2. That if, at any time, it become apparent that the current created by such drainage works in the South and Main Branches of Chicago River, be unreasonably obstructive to navigation or injurious to property, the Secretary of War reserves the right to close said discharge

through said channel or to modify it to such extent as may be demanded by navigation and property interests along said Chicago River and its South Branch.

"3. That the Sanitary District of Chicago must assume all responsibility for damages to property and navigation interests by reason of the introduction of a current in Chicago River.

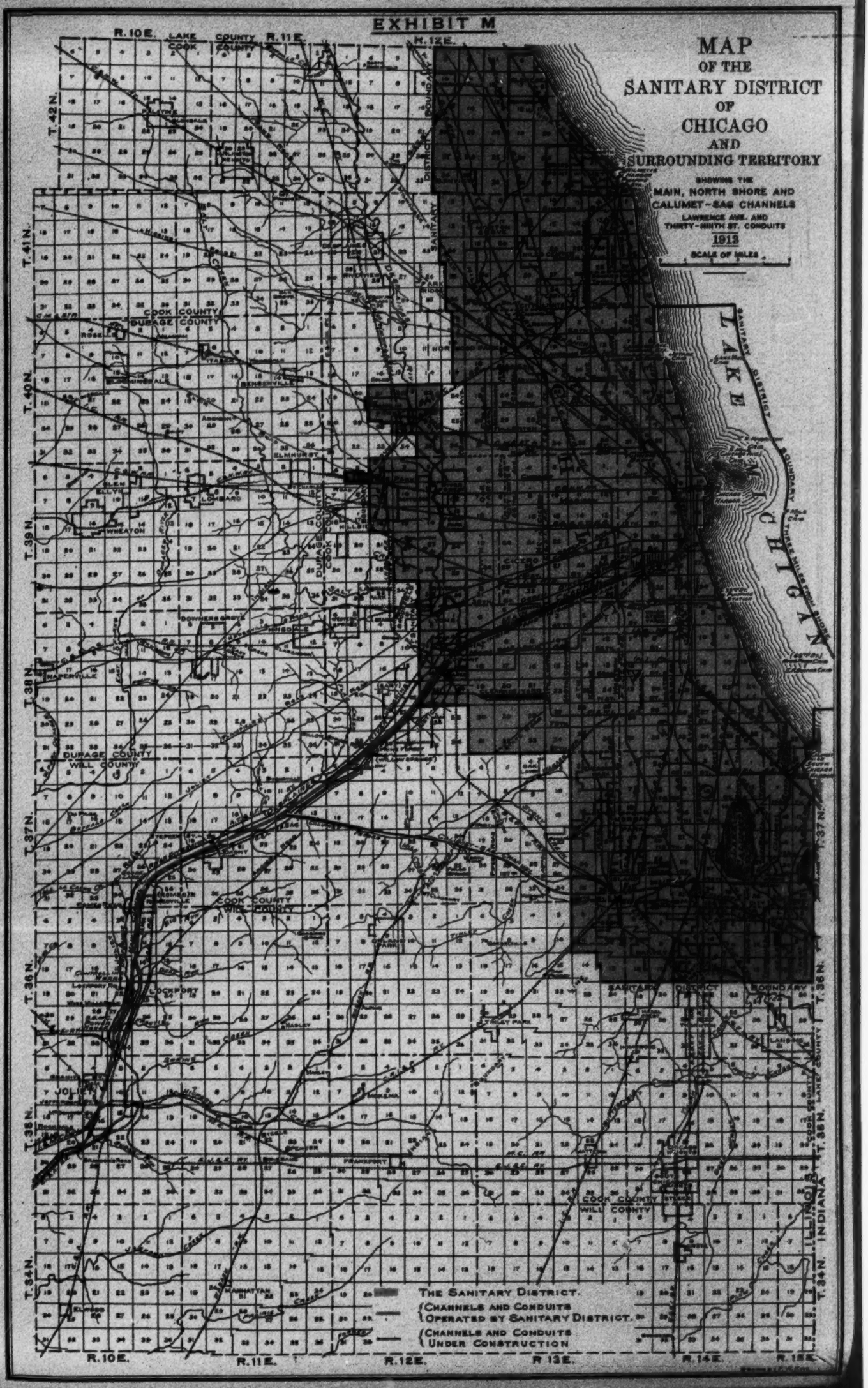
Very respectfully,

ELIHU ROOT,
Secretary of War.

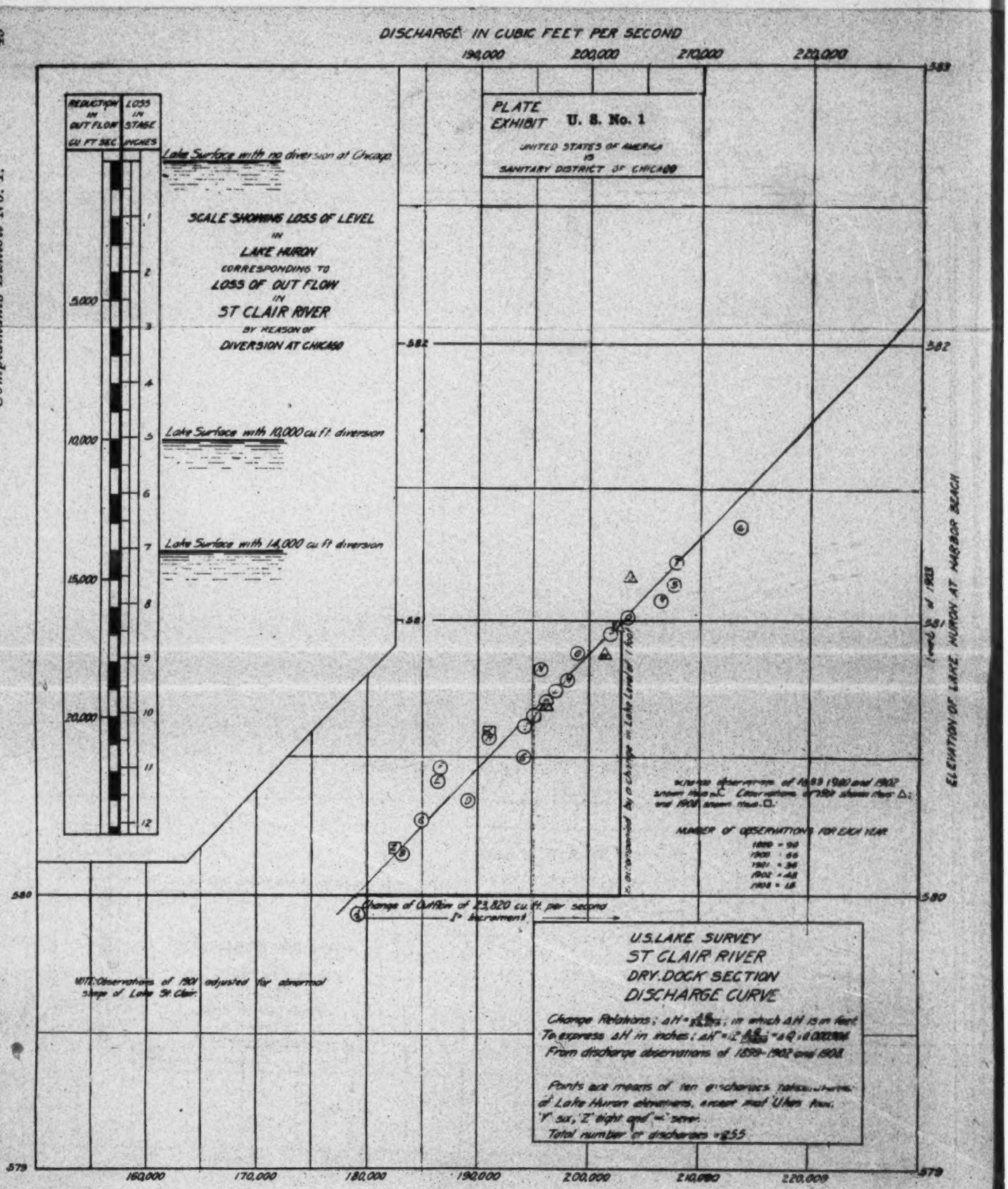
Mr. Wm. Boldenweck,
President the Sanitary District of Chicago,
Security Building, Chicago, Ills."

Exhibits Attached to Answer.

EXHIBIT M



Complainants Exhibit No. 1.



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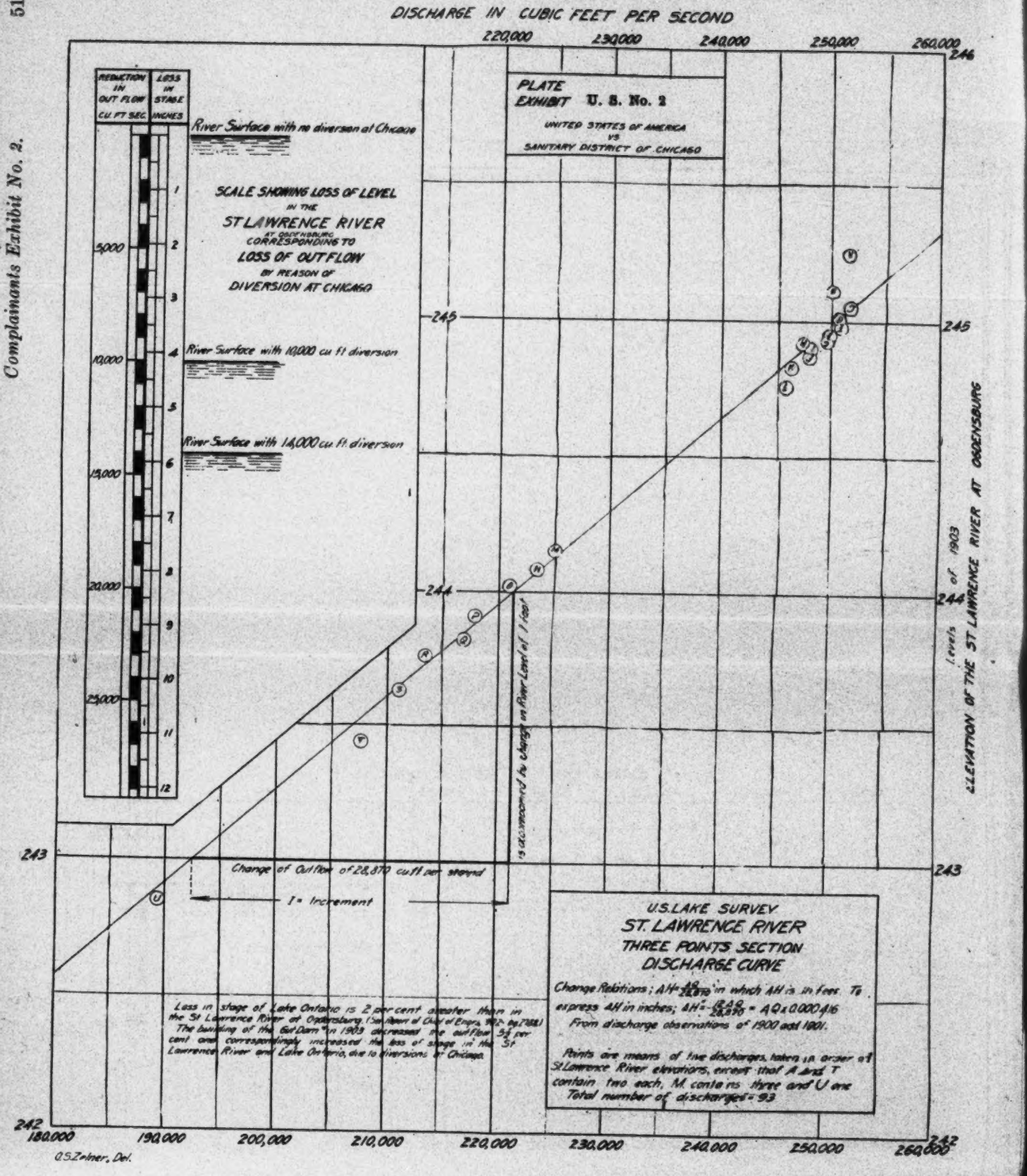

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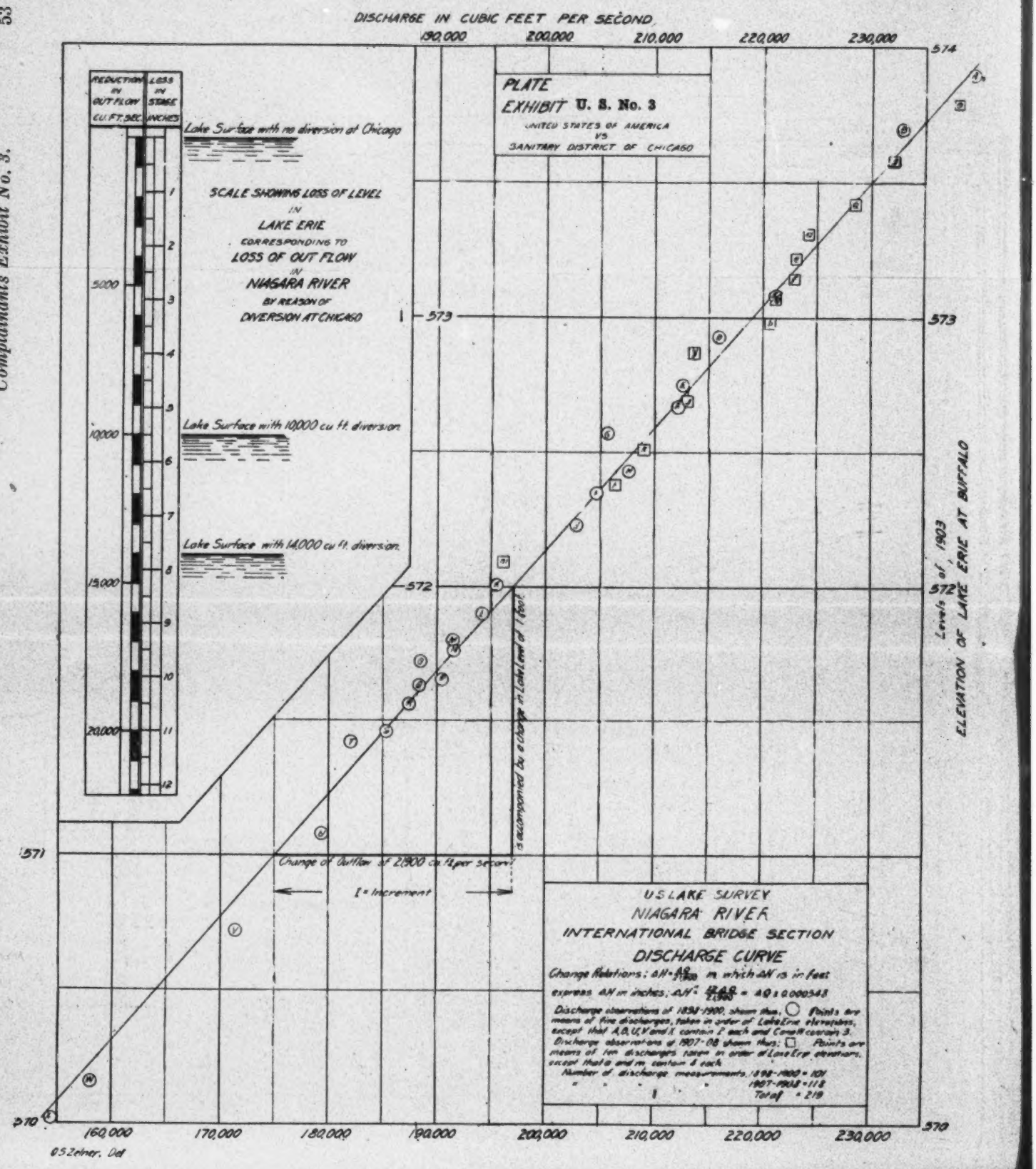

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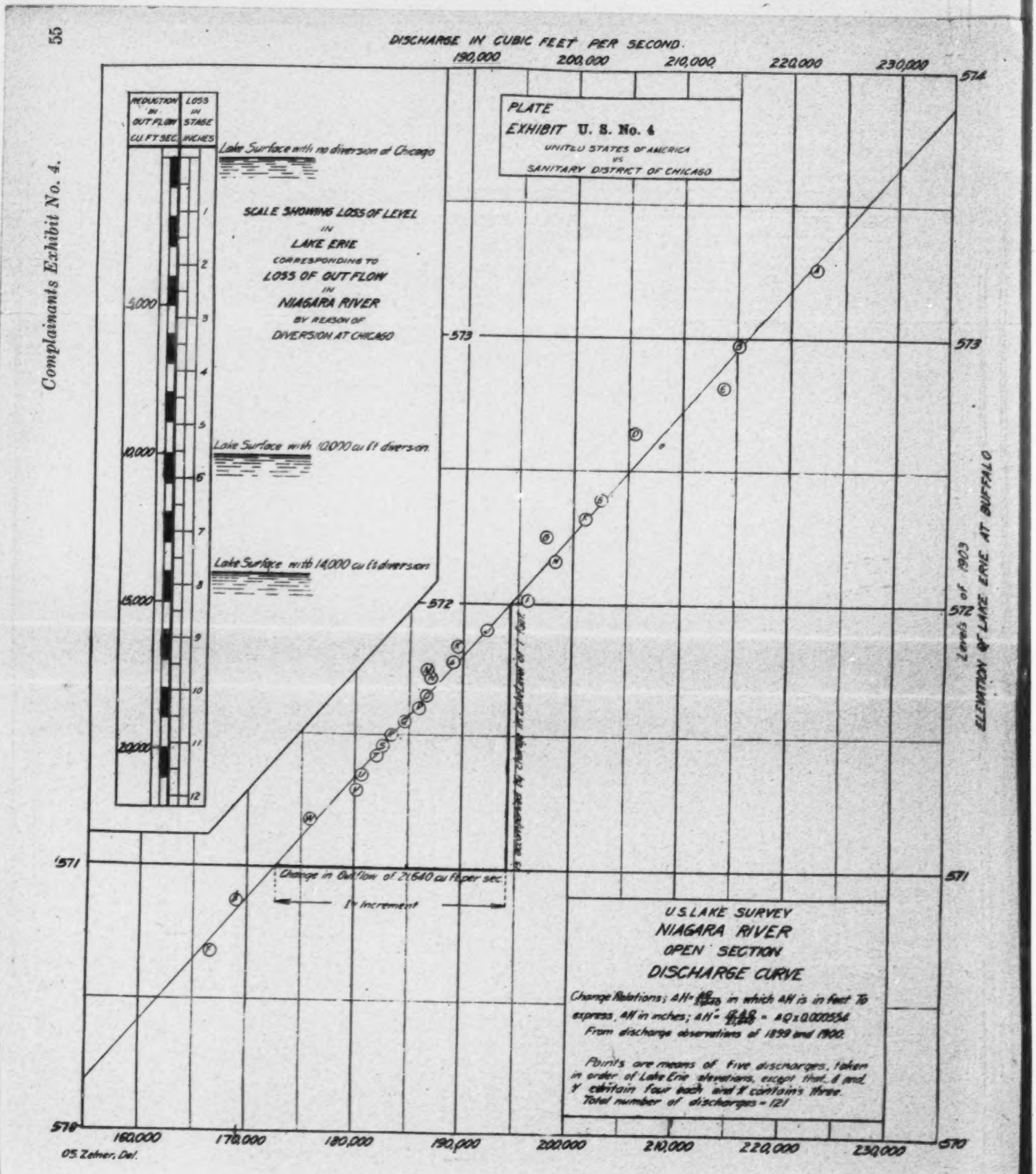
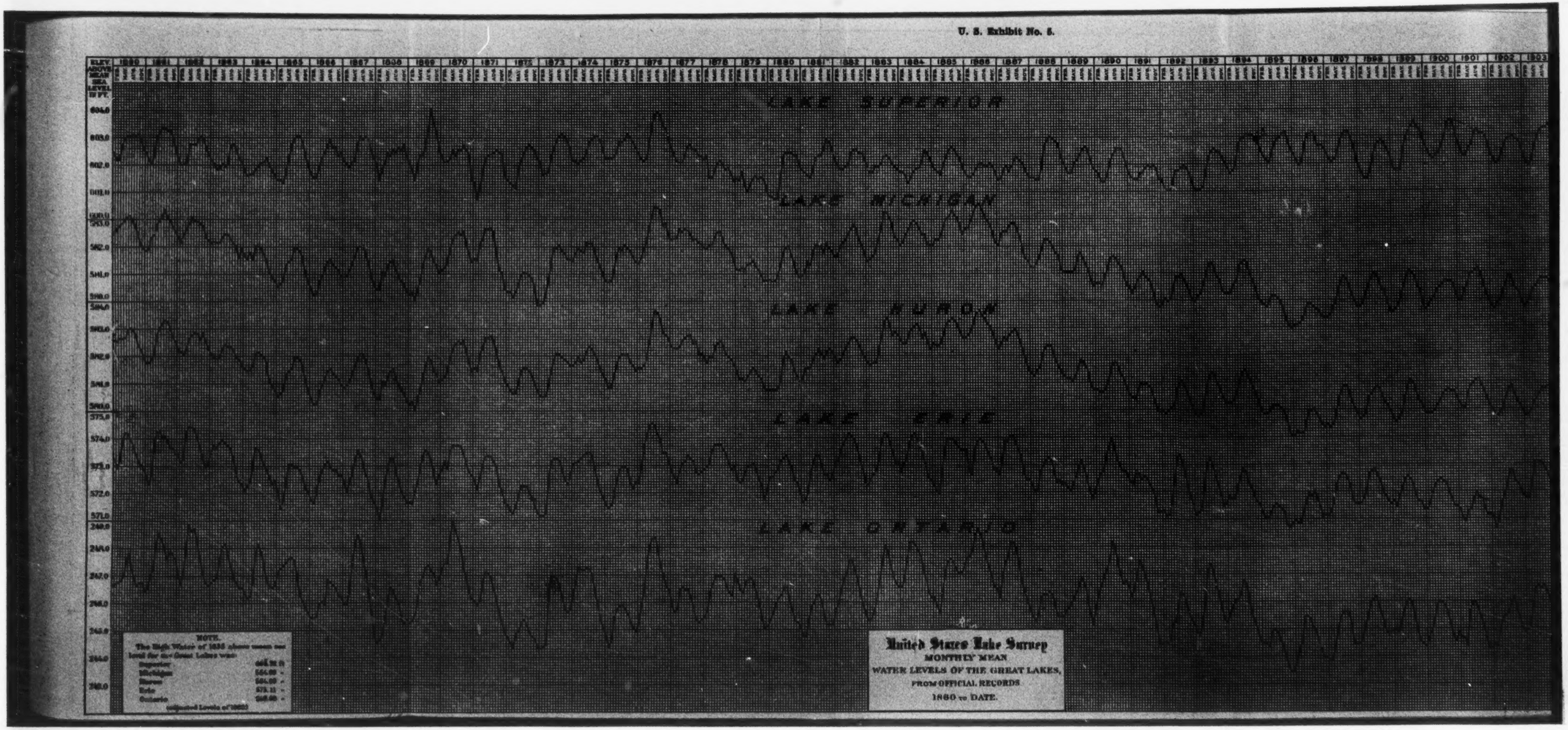
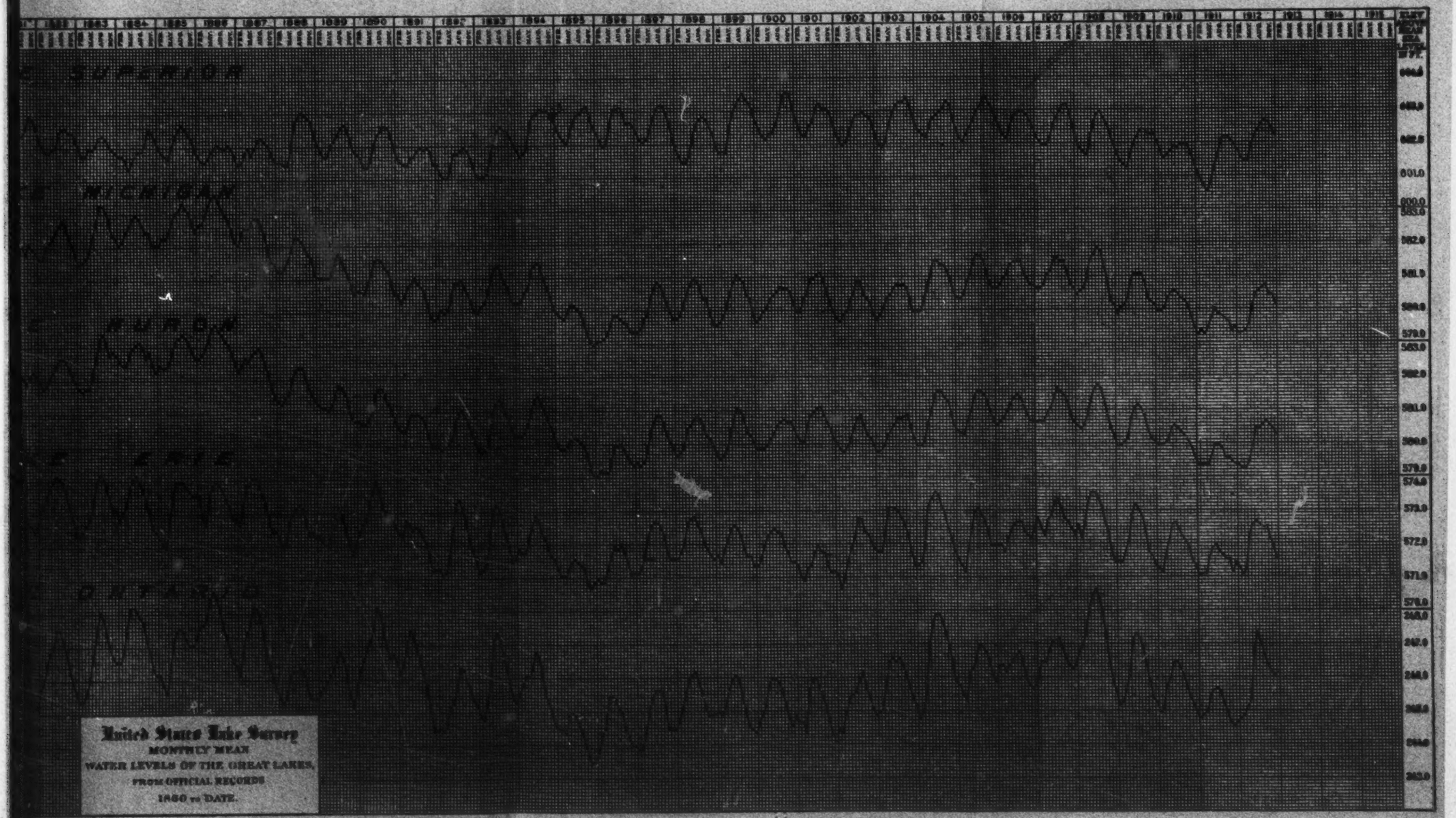
Complainants Exhibit No. 4.



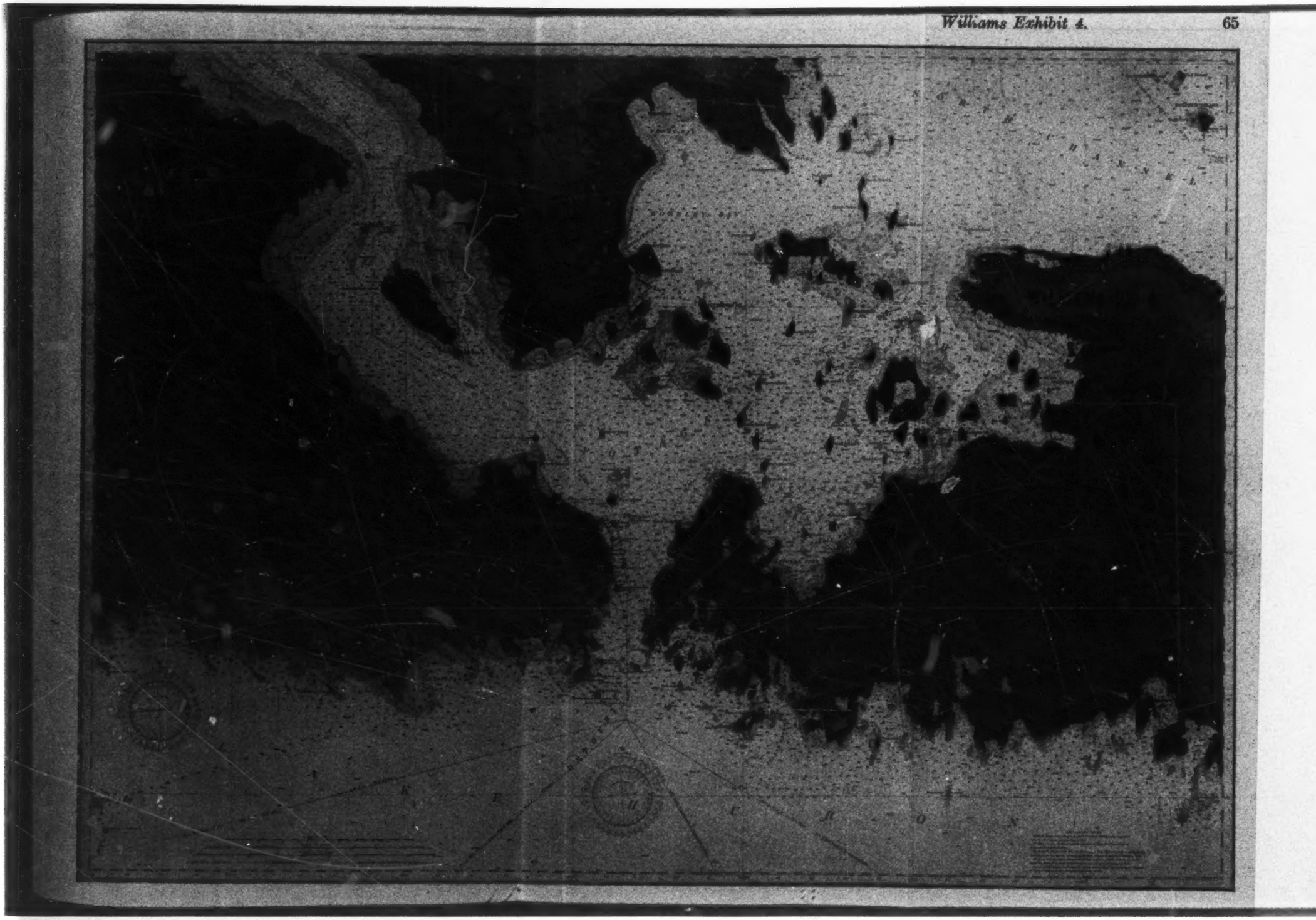
U. S. Exhibit No. 5.

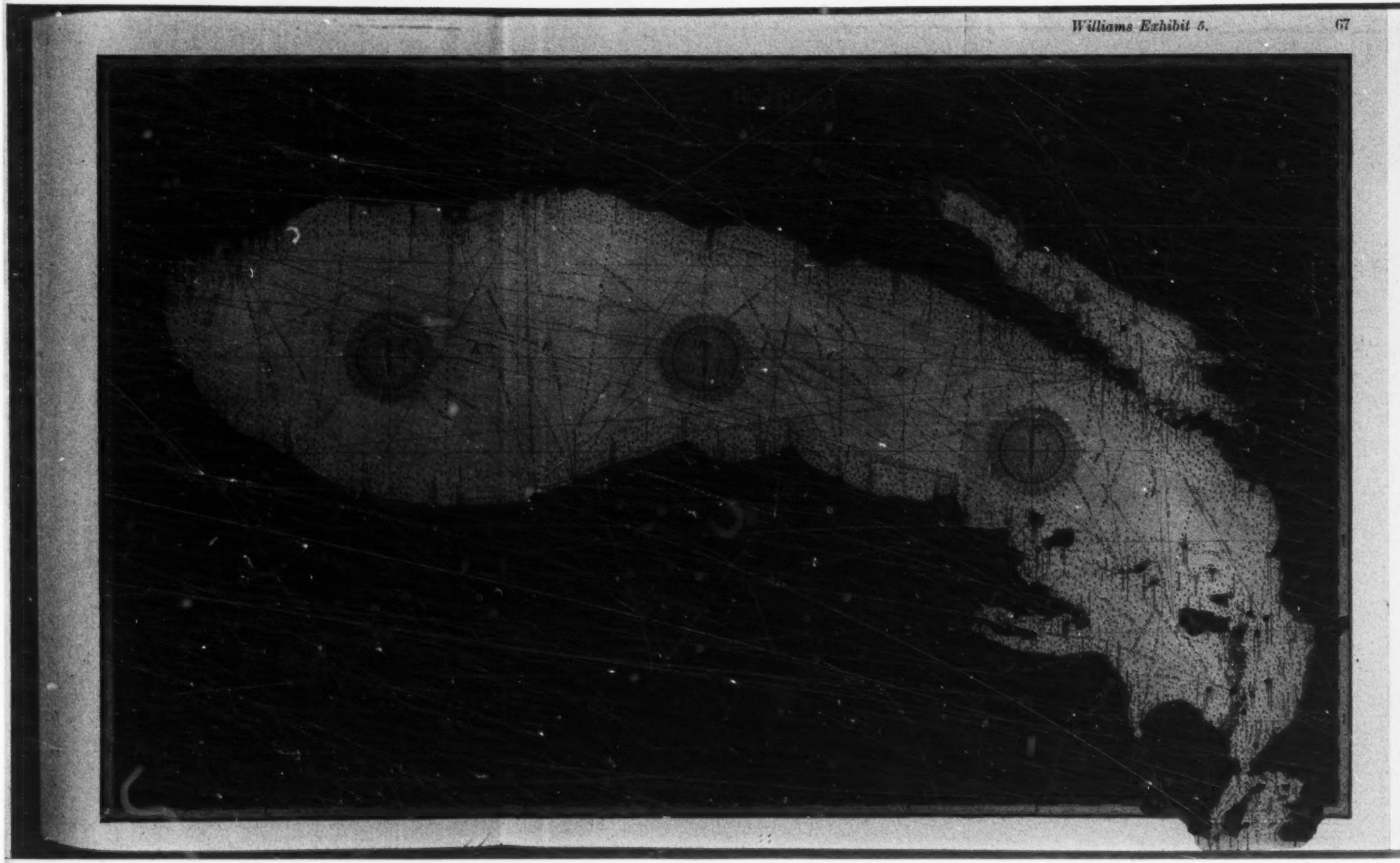




United States Lake Survey
MONTHLY MEAN
WATER LEVELS OF THE GREAT LAKES.
FROM OFFICIAL RECORDS
1860 TO DATE.

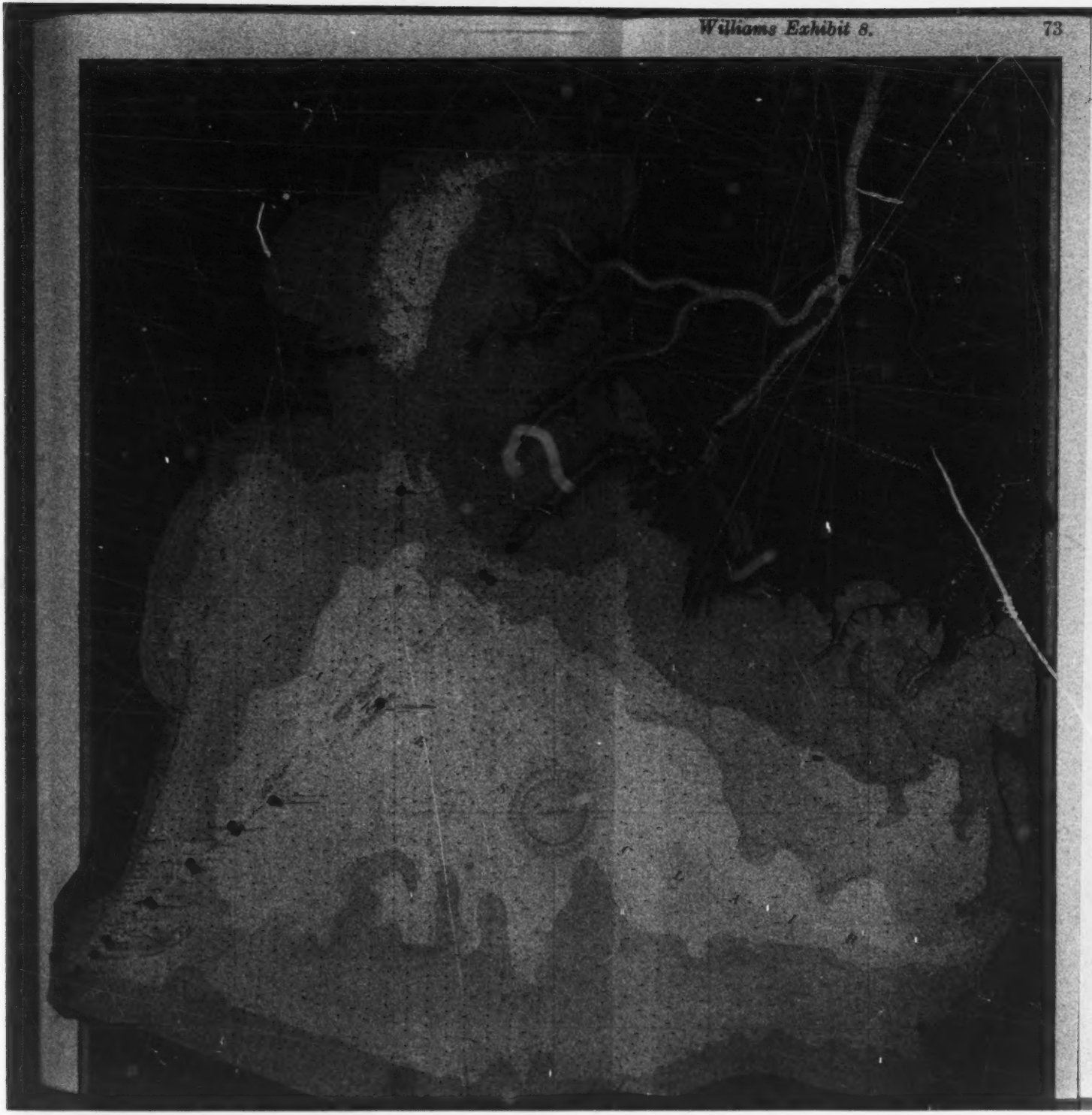
WHITEFISH BAY
HEAD O

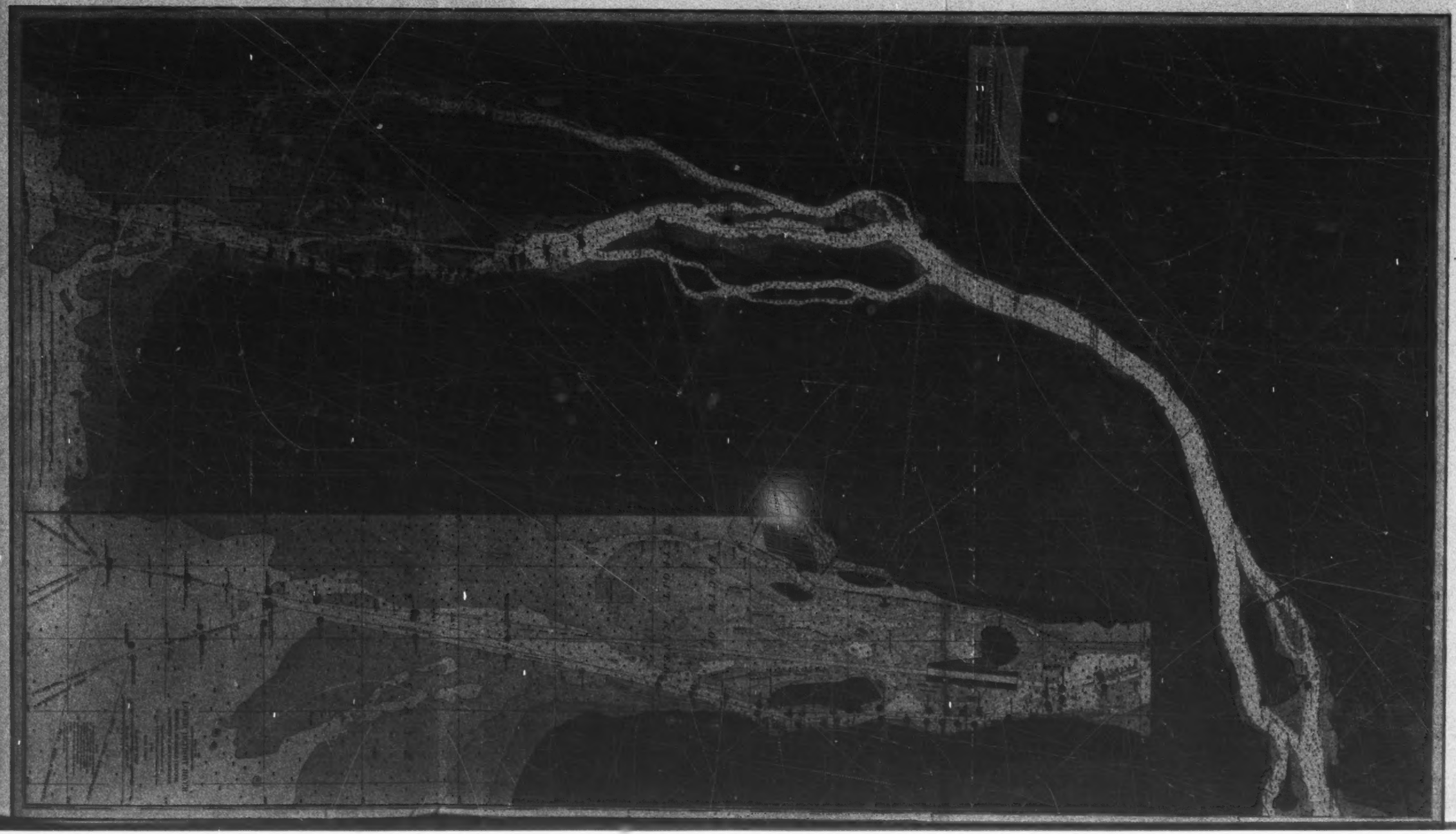

GREAT BRITAIN
IRELAND
EUROPE



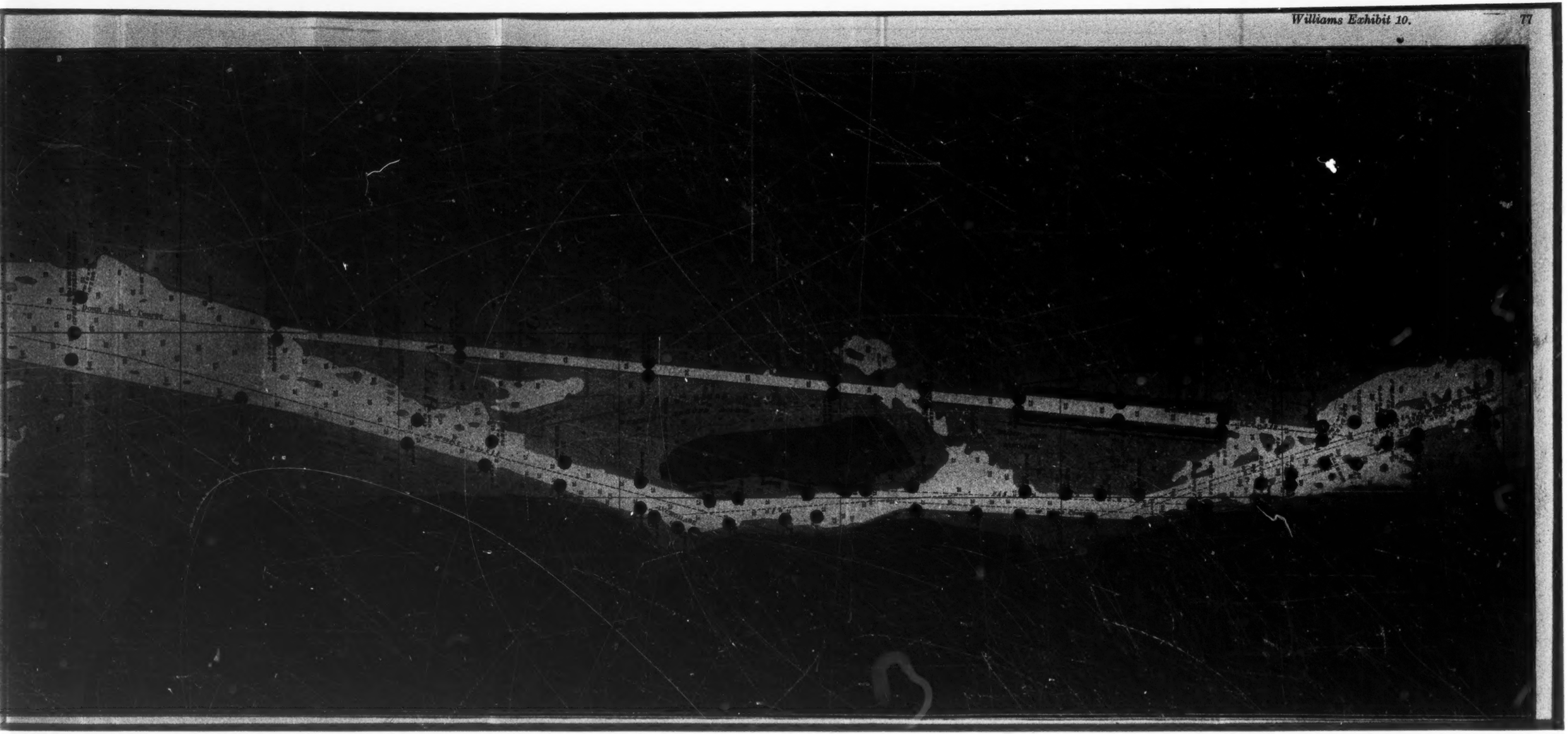
L A K E
H U R O N

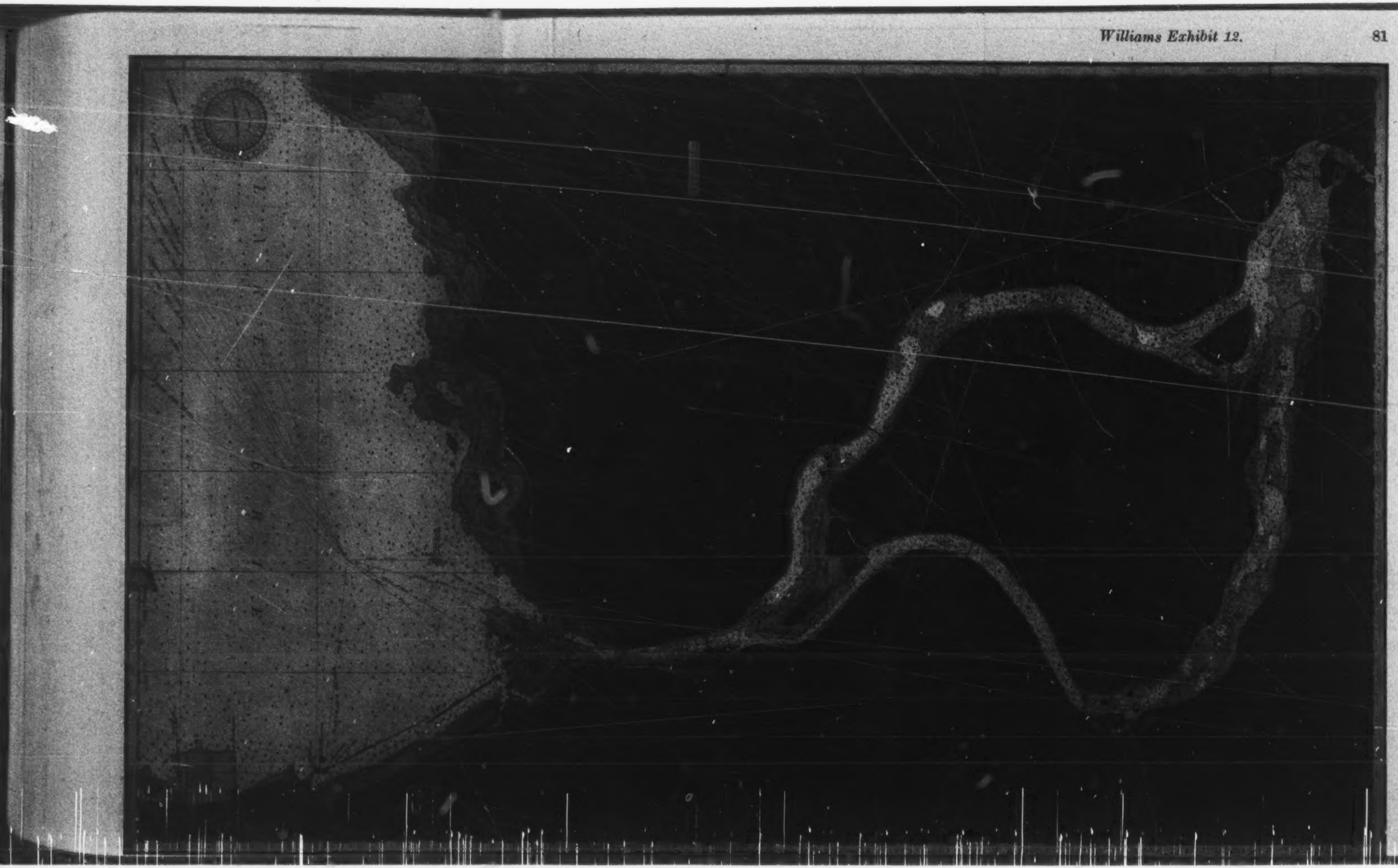
SAINT CLAIR RIVER

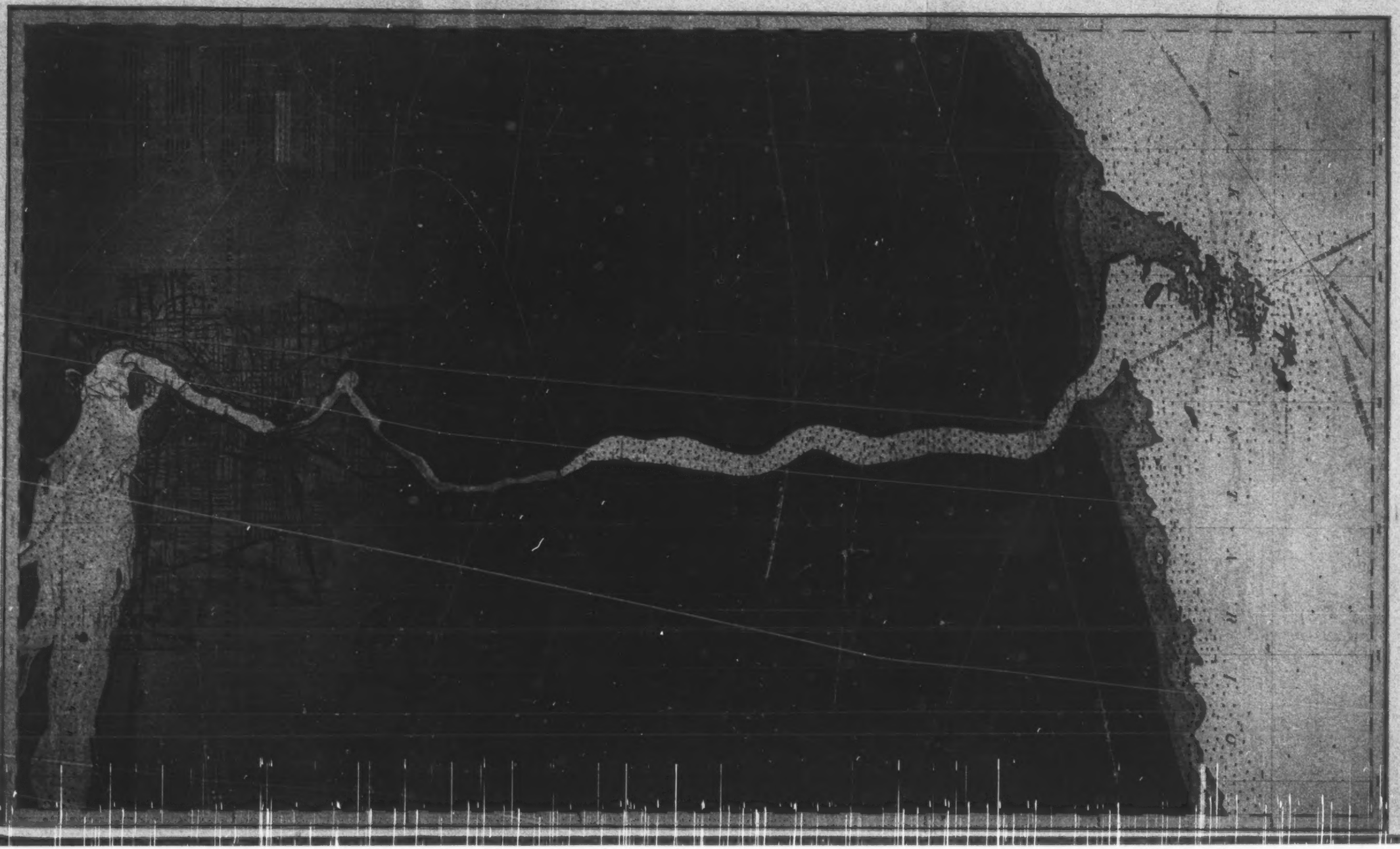


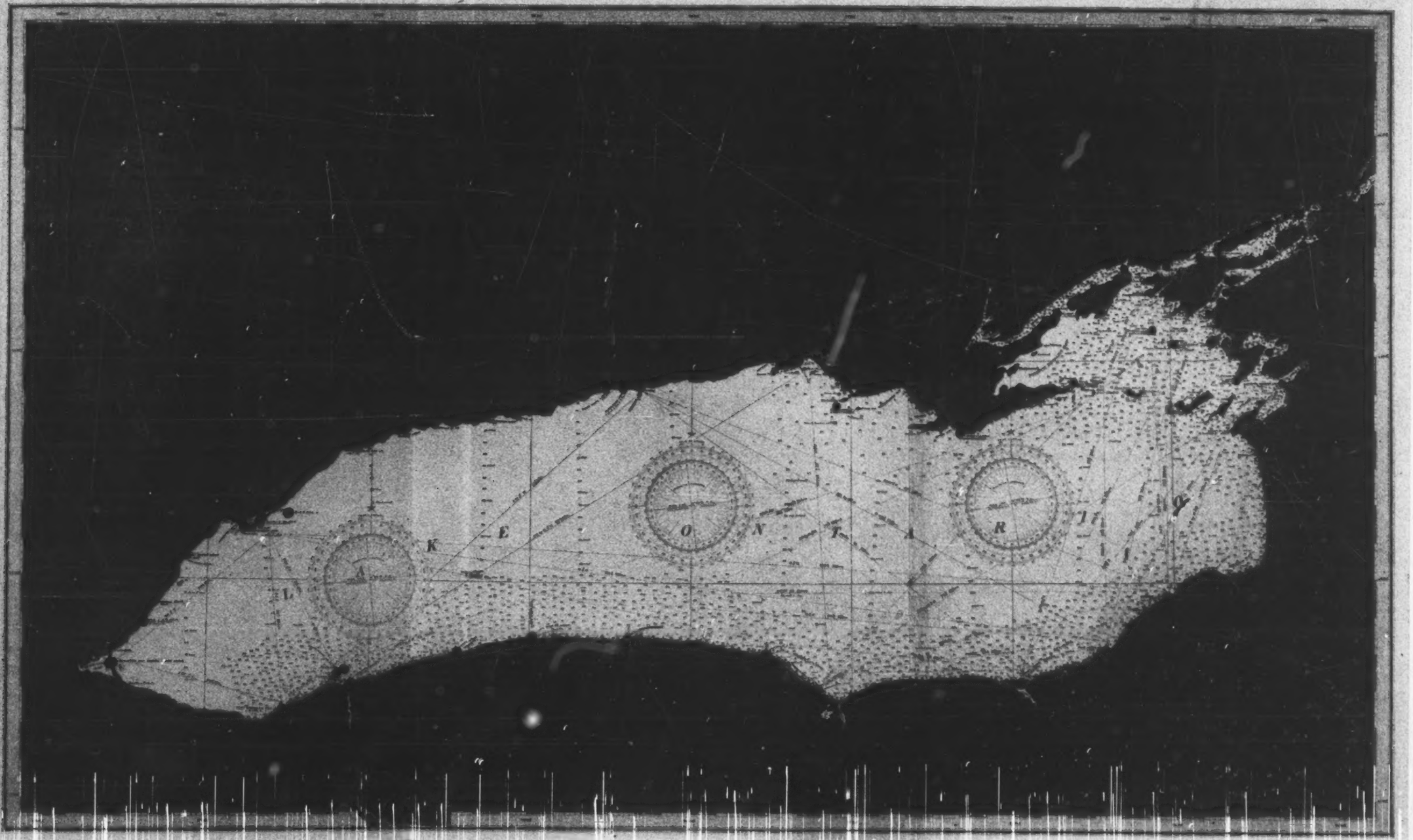


LOWER DETROIT RIVER
SHOWING LIVINGSTONE CHANNEL
AND POSITIONS OF AIDS TO NAVIGATION
Lieut.-Col. JOHN MAVITY, Corps of Engineers, U.S. Army, to 1912, and
Lieut.-Col. J.C. SANFORD, Corps of Engineers, U.S. Army
to 1913.
SCALE 1:32000.
NOTE.
Sailing lines
Range lines








K E
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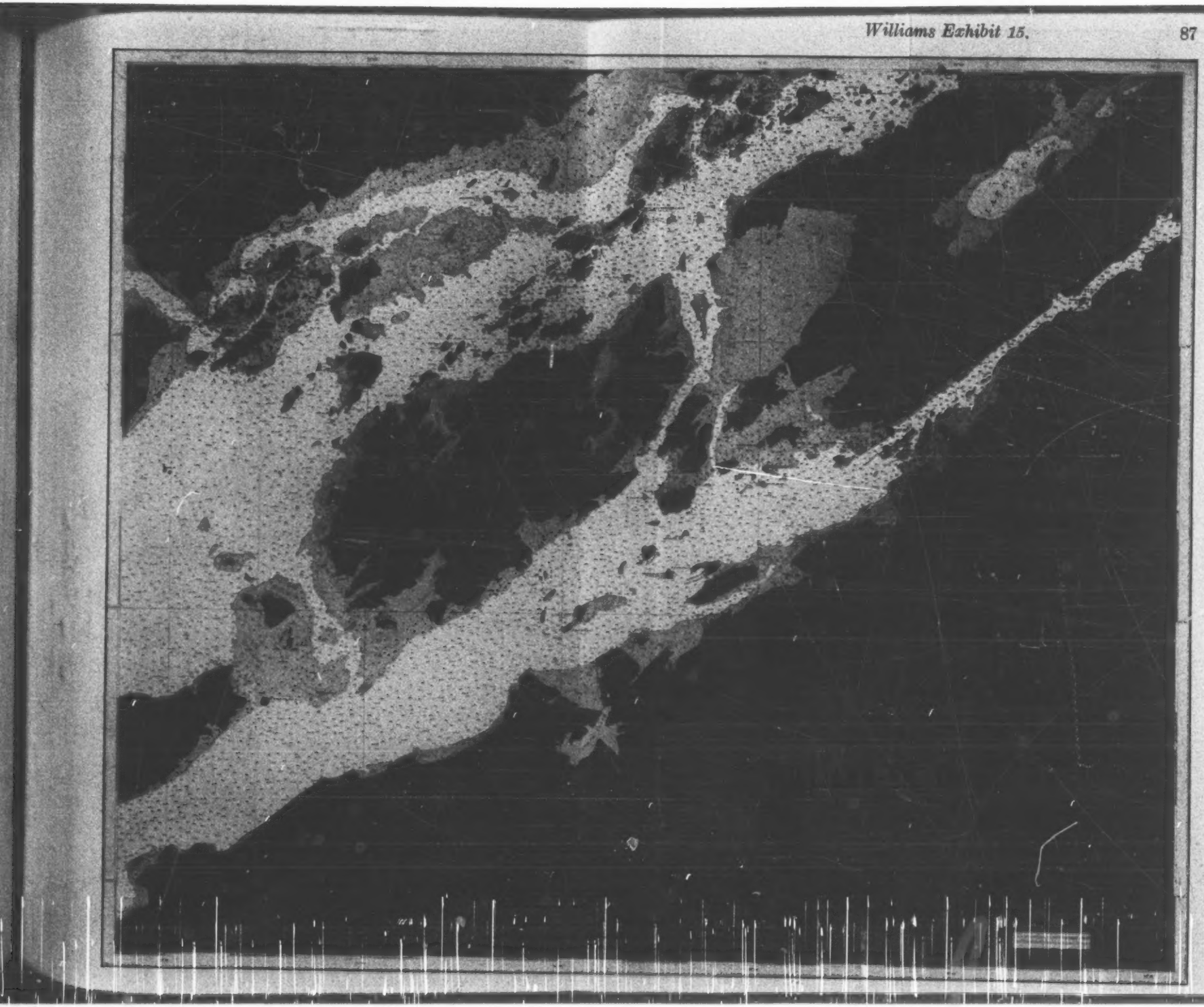
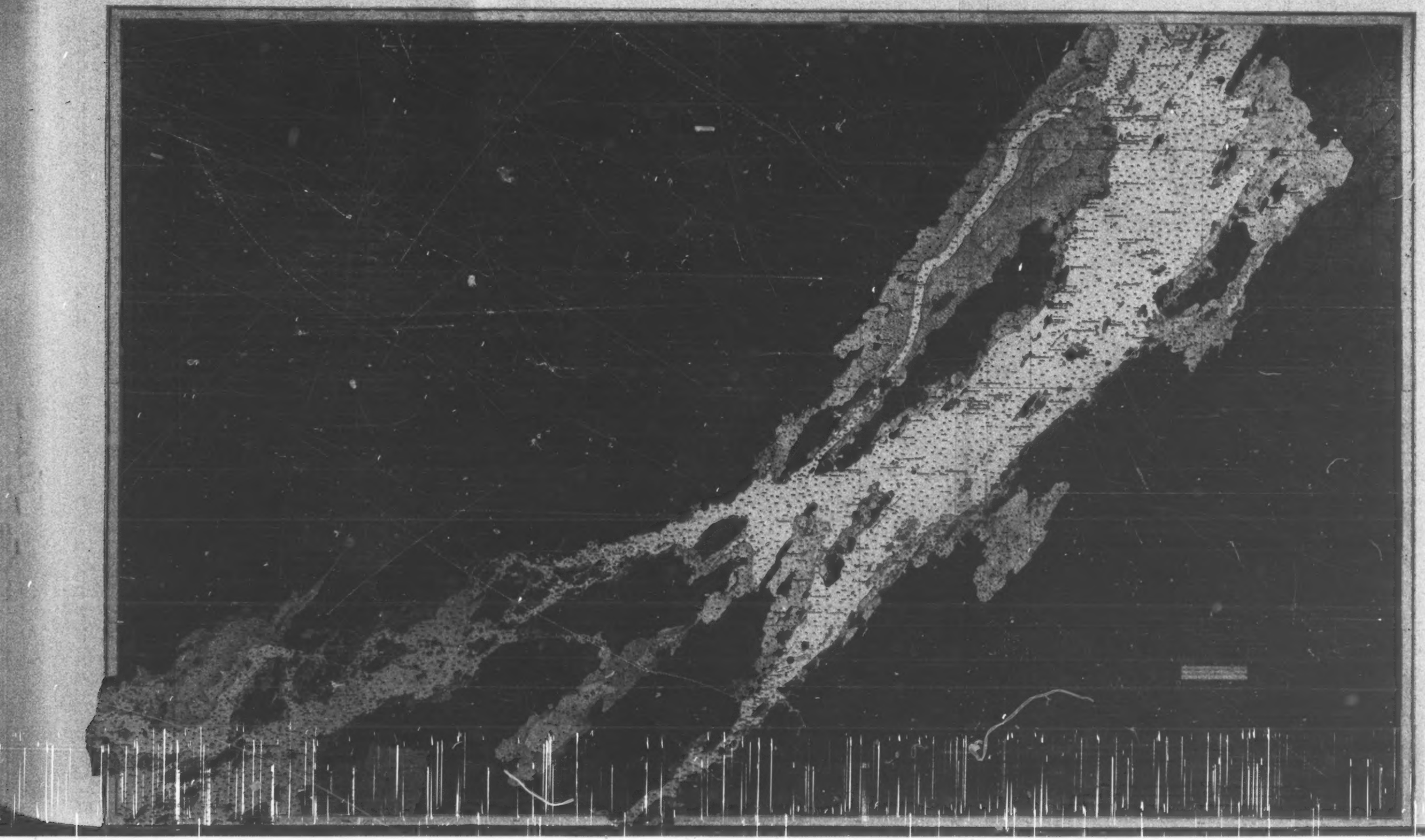
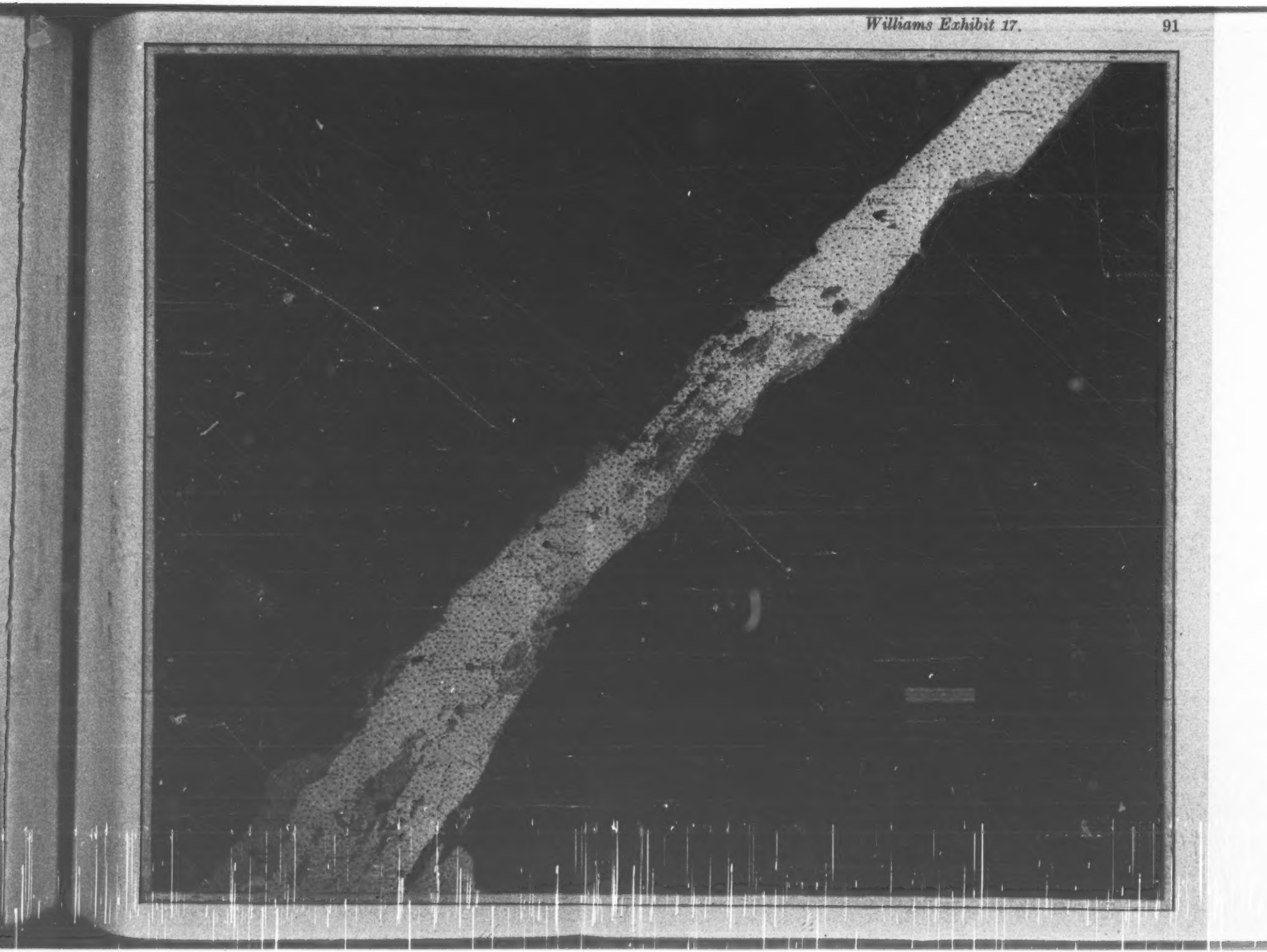
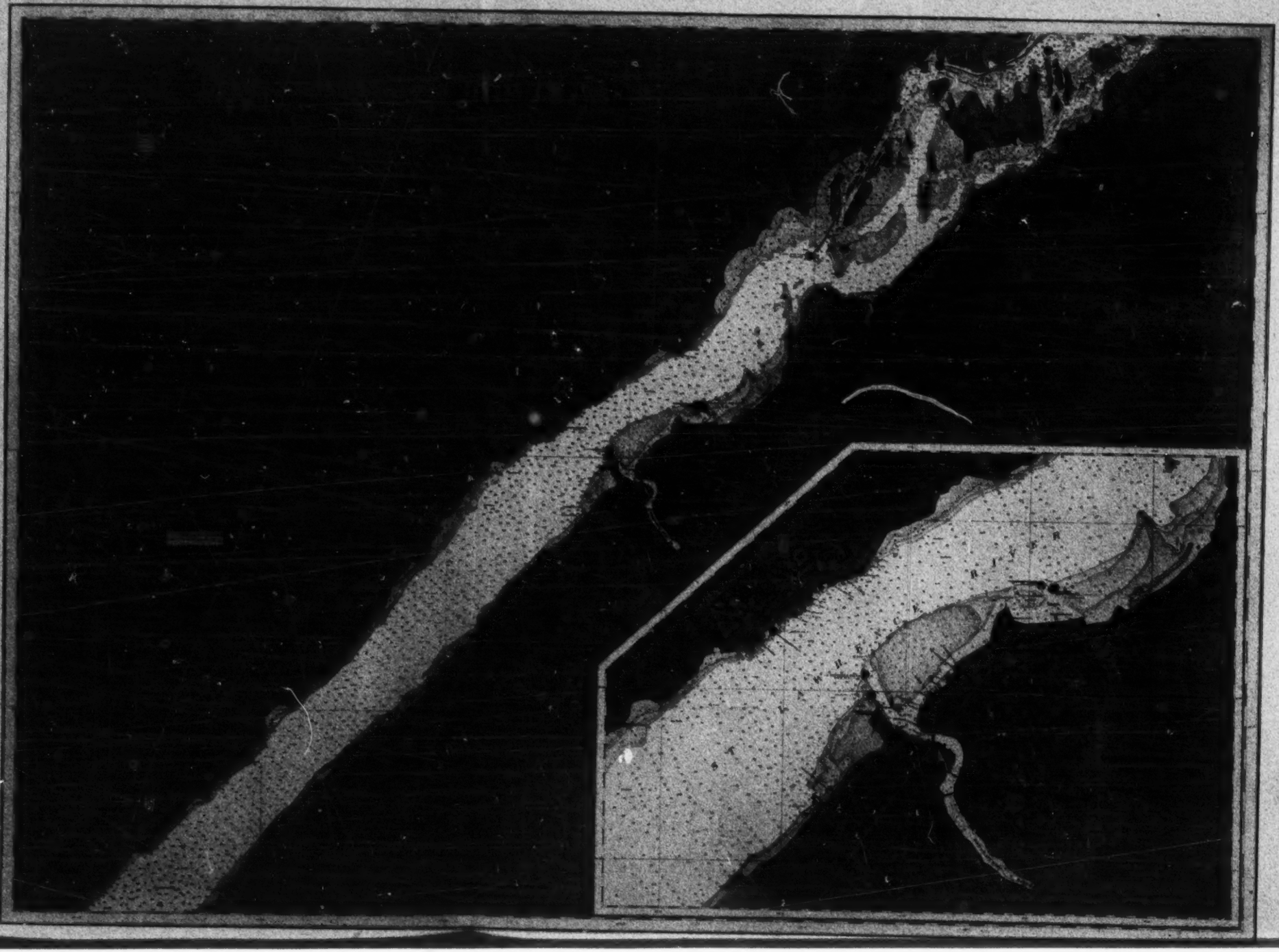
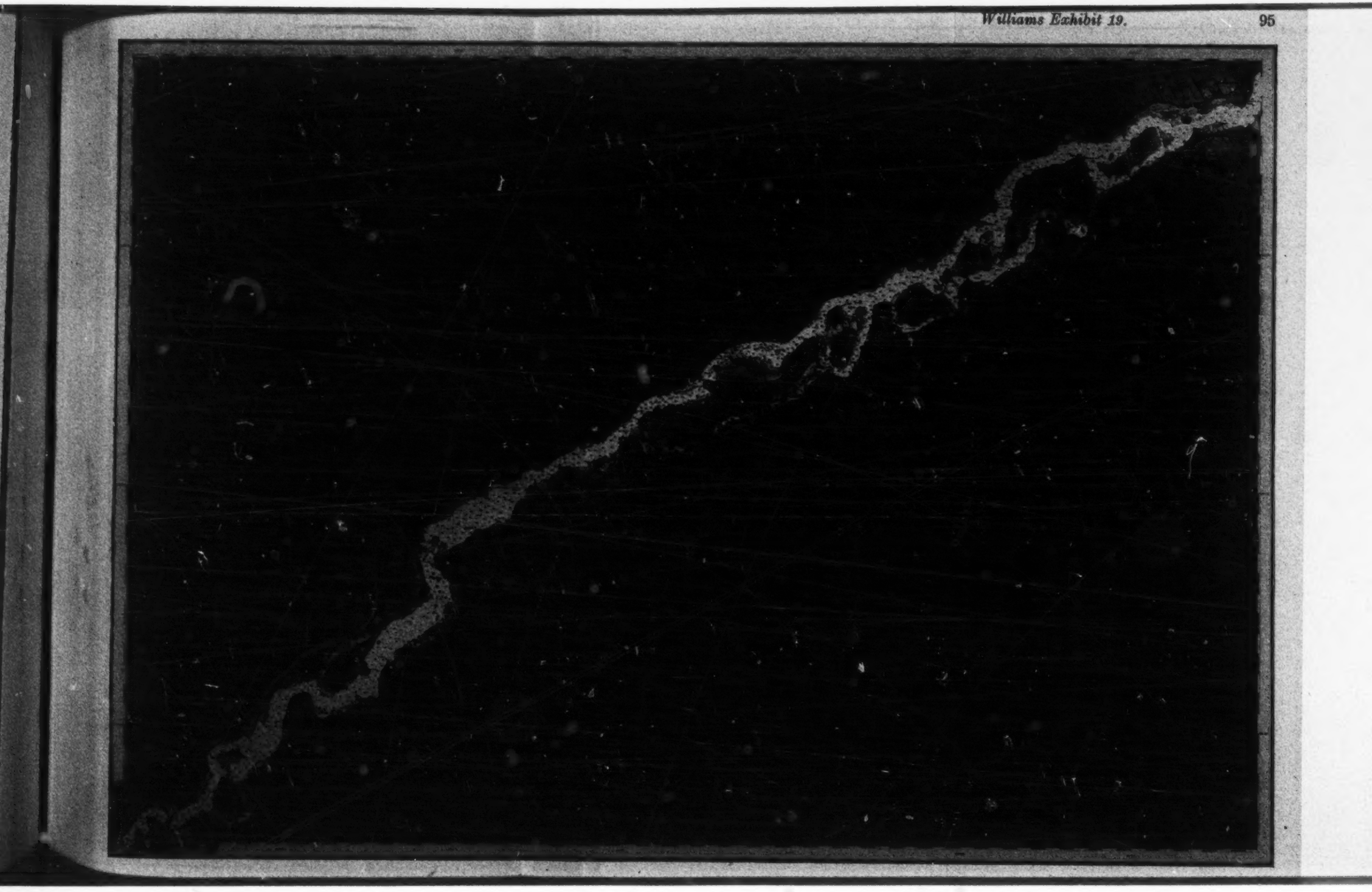
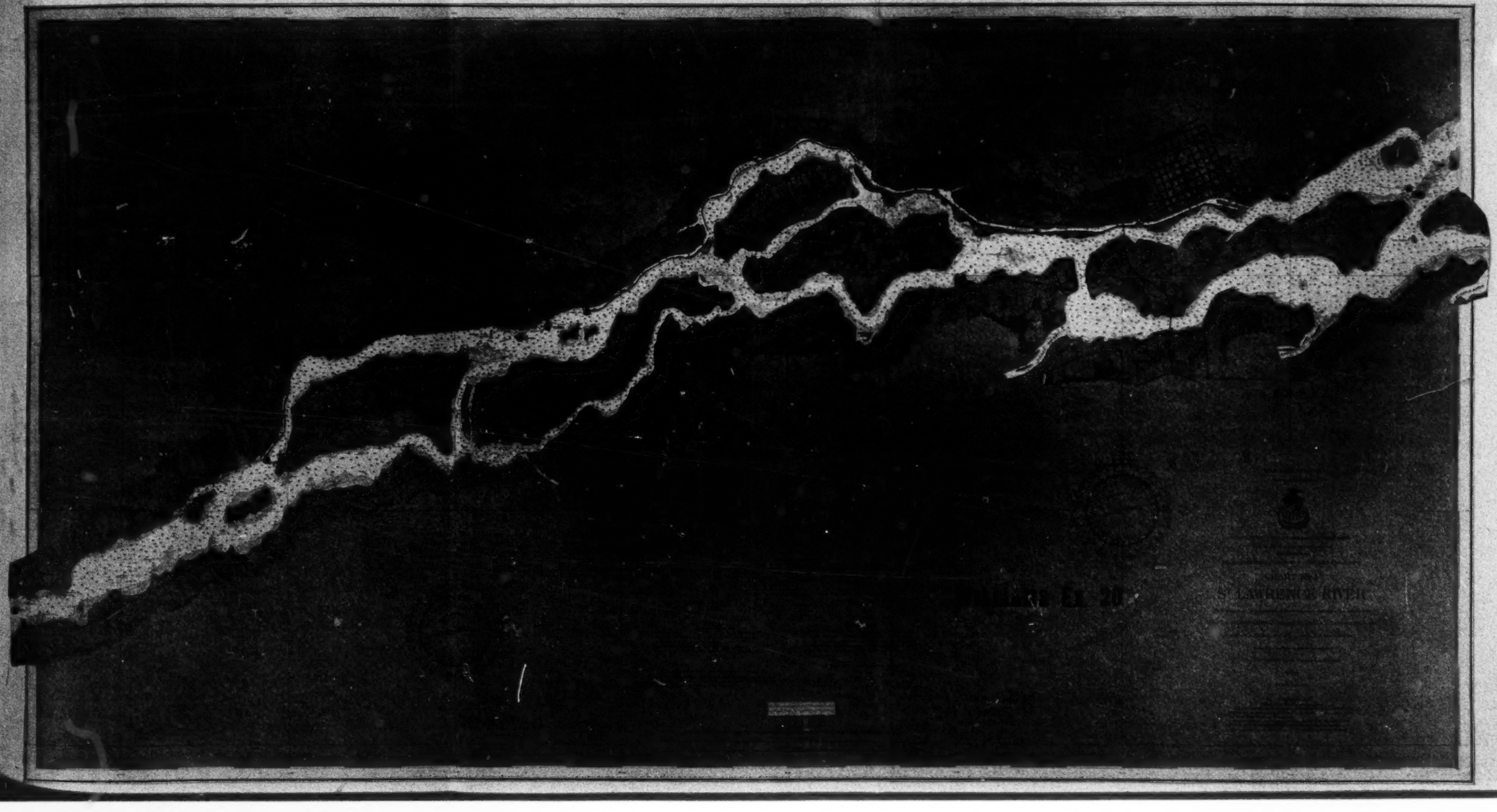











WILLIAMS EX. 20
ST. LAWRENCE RIVER

Williams Ex. 21

U. S. LAKE SURVEY
Discharge Measurements—Dry Dock Section
ST. CLAIR RIVER
1899-1900-1902

1-Table
Sheet 1
(7 Sheets)

No. of Meas.	Date	Water Surface		Fall	Rise+ Fall—	WIND		Discharge Cu. Ft. per Sec.
		Lake Huron	St. Clair Flats			Dir.	Vel.	
154	Dec. 22, 1900	579.65	574.66	4.99		S.W.	25	174,200
89	Nov. 17, 1899	9.71	4.66	5.05		S.E.	17	174,000
153	Dec. 21, 1900	9.90	4.66	5.24		S	18	175,900
2	May 1, 1899	9.93	4.91	5.02		S.E.	20	183,600
81	Nov. 22, 1899	9.97	4.66	5.31		S	18	180,300
87	Dec. 1, 1899	580.00	4.86	5.14		S.W.	20	177,900
156	Dec. 27, 1900	0.00	4.66	5.34		S.W.	16	179,700
65	Oct. 16, 1899	0.03	4.86	5.17		S	16	180,300
149	Dec. 17, 1900	0.03	4.71	5.32		S.E.	16	183,500
150	Dec. 18, 1900	0.04	4.71	5.33		S.E.	15	182,100
A Means	Group 1....	579.93	574.74	5.19				179,200
217	Sept. 6, 1902	580.05	575.26	4.79		S.W.	15	170,700
86	Nov. 29, 1899	0.10	4.66	5.44		S.W.	12	181,400
1	Apr. 29, 1899	0.11	4.91	5.20		S.	10	188,000
84	Nov. 27, 1899	0.16	4.66	5.50		S.W.	6	186,500
61	Oct. 10, 1899	0.16	4.86	5.30		S.E.	16	180,900
63	Oct. 13, 1899	0.17	4.86	5.31		S.	15	184,500
78	Nov. 15, 1899	0.17	4.66	5.51		S.W.	10	185,700
85	Nov. 28, 1899	0.18	4.66	5.52		S.W.	15	185,400
70	Oct. 23, 1899	0.20	4.76	5.44		S.E.	14	183,000
144	Dec. 8, 1900	0.21	4.81	5.40		S.W.	12	185,600
B Means	Group 2....	580.15	574.81	5.34				183,200
239	Sept. 25, 1902	580.21	575.36	4.85		E.	10	179,200
137	Nov. 30, 1900	0.22	4.81	5.41		S.W.	20	182,500
151	Dec. 19, 1900	0.24	4.71	5.53		S.W.	15	185,300
79	Nov. 16, 1899	0.25	4.66	5.59		E.	10	187,600
83	Nov. 24, 1899	0.26	4.66	5.60		E.	4	192,900
4	May 4, 1899	0.28	4.96	5.32		E.	9	189,700
229	Sept. 17, 1902	0.30	5.16	5.14		S.E.	7	179,000
98	July 2, 1900	0.30	5.16	5.14		S.	12	182,400
93	June 21, 1900	0.31	5.16	5.15		S.W.	12	188,200
100	July 5, 1900	0.31	5.16	5.15		S.W.	14	182,200
C Means	Group 3....	580.27	574.98	5.29				184,900
82	Nov. 23, 1899	580.32	574.66	5.66		N.E.	17	195,200
6	May 6, 1899	0.32	4.96	5.36		S.	7	194,200
227	Sept. 16, 1902	0.32	5.16	5.16		S.	6	186,500
230	Sept. 17, 1902	0.32	5.16	5.16		S.	10	181,700
5	May 5, 1899	0.33	4.96	5.37		W.	7	190,900
155	Dec. 26, 1900	0.33	4.66	5.67		N.W.	10	194,200
62	Oct. 11, 1899	0.34	4.86	5.48		S.	13	190,000
99	July 3, 1900	0.34	5.16	5.18		S.W.	20	182,500
219	Sept. 8, 1902	0.36	5.26	5.10		S.W.	12	184,000
92	June 20, 1900	0.39	5.16	5.23		N.E.	10	191,700
D Means	Group 4....	580.34	575.00	5.34				189,100

Williams Ex. 21

2-Table Sheet 1 (7 Sheets)

U. S. LAKE SURVEY

Discharge Measurements—Dry Dock Section

ST. CLAIR RIVER

1899-1900-1902

	No. of Meas.	Date	Water Surface		Fall	Rise+ Fall-	Wind		Discharge Cu. Ft. per Sec.
			Lake Huron	St. Clair Flats			Dir.	Vel.	
	88	Dec. 2, 1899	580.39	574.86	5.53		S.W.	16	190,300
	10	May 31, 1899	0.39	5.21	5.18		S.	18	186,300
	139	Dec. 3, 1900	0.39	4.81	5.58		S.W.	10	191,200
	226	Sept. 15, 1902	0.39	5.26	5.13		S.W.	15	177,900
	131	Nov. 8, 1900	0.40	4.91	5.49		N.W.	12	191,600
	212	Sept. 3, 1902	0.41	5.26	5.15		S.W.	17	176,600
	94	June 22, 1900	0.42	5.16	5.26		E.	12	190,300
	148	Dec. 15, 1900	0.42	4.71	5.71		S.E.	6	193,800
	240	Sept. 26, 1902	0.43	5.46	4.97		S.	6	182,600
	225	Sept. 15, 1902	0.43	5.26	5.17		S.W.	13	182,100
E	Means	Group 5.....	580.41	575.09	5.32				186,300
	235	Sept. 22, 1902	580.44	575.16	5.28		S.W.	4	184,100
	231	Sept. 18, 1902	0.45	5.16	5.29		S.	9	183,500
	218	Sept. 6, 1902	0.46	5.26	5.20		S.W.	12	184,000
	8	May 25, 1899	0.46	5.16	5.30		S.W.	14	194,000
	90	Dec. 6, 1899	0.46	4.56	5.90		N.W.	20	198,800
	130	Sept. 19, 1900	0.47	5.11	5.36		S.E.	10	187,300
	220	Sept. 8, 1902	0.47	5.26	5.21		S.W.	20	176,700
	228	Sept. 16, 1902	0.47	5.16	5.31		S.	12	179,800
	142	Dec. 6, 1900	0.48	4.81	5.67		S.W.	12	190,200
	234	Sept. 22, 1902	0.48	5.16	5.32		S.W.	4	187,800
F	Means	Group 6.....	580.46	575.08	5.38				186,600
	138	Dec. 1, 1900	580.48	574.81	5.67		N.W.	12	196,800
	140	Dec. 4, 1900	0.48	4.81	5.67		N.W.	12	196,000
	9	May 29, 1899	0.49	5.21	5.28		S.	16	194,400
	72	Oct. 27, 1899	0.50	4.76	5.74		N.E.	10	196,900
	67	Oct. 18, 1899	0.51	4.86	5.65		S.W.	13	194,400
	91	June 19, 1900	0.51	5.16	5.35		N.E.	12	194,400
	129	Sept. 19, 1900	0.51	5.11	5.40		S.E.	14	185,700
	3	May 3, 1899	0.52	4.96	5.56		N.E.	15	191,200
	89	Dec. 4, 1899	0.52	4.56	5.96		N.W.	20	200,900
	95	June 25, 1900	0.53	5.16	5.37		N.E.	10	191,400
G	Means	Group 7.....	580.50	574.94	5.56				194,300
	102	July 7, 1899	580.54	57[illegible].16	5.38		S.W.	11	190,700
	236	Sept. 23, 1902	0.54	5.21	5.33		N.	5	187,900
	152	Dec. 20, 1900	0.55	4.[illegible]	5.89		N.W.	10	194,800
	69	Oct. 20, 1899	0.57	4.[illegible]	5.81		N.E.	12	200,400
	116	Aug. 4, 1900	0.57	5.[illegible]	.21		S.W.	11	186,900
	238	Sept. 24, 1902	0.57	5.[illegible]	.36		E.	20	190,800
	224	Sept. 13, 1902	0.58	5.[illegible]	.32		W.	15	187,000
	18	June 12, 1899	0.58	5.26	.22		S.	20	194,400
	233	Sept. 20, 1902	0.59	5.21	5.38		S.E.	3	188,600
	222	Sept. 11, 1902	0.59	.21	5.38		S.W.	12	190,100
H	Means	Group 8.....	580.57	575.14	5.43				191,900

Williams Ex. 21

3-Table Sheet 3 (7 Sheets)

U. S. LAKE SURVEY

Discharge Measurements—Dry Dock Section

ST. CLAIR RIVER

1899–1900–1902

No. of Meas.	Date	Water Surface		Fall	Rise+ Fall—	Wind		Discharge Cu. Ft. per Sec.
		Lake Huron	St. Clair Flats			Dir.	Vel.	
221	Sept. 10, 1902	580.59	575.26	5.33		S.W.	15	184,800
133	Nov. 10, 1900	0.60	4.86	5.74		S.W.	7	198,400
136	Nov. 16, 1900	0.60	4.86	5.74		S.W.	10	197,200
13	June 5, 1899	0.60	5.27	5.33		S.W.	18	196,000
68	Oct. 19, 1899	0.61	4.86	5.75		N.	9	197,600
71	Oct. 27, 1899	0.61	4.76	5.85		N.E.	9	198,800
115	Aug. 4, 1900	0.61	5.36	5.25		S.W.	10	188,200
123	Sept. 10, 1900	0.62	5.26	5.36		S.W.	8	191,600
124	Sept. 10, 1900	0.62	5.26	5.36		S.W.	7	190,400
12	June 3, 1899	0.62	5.26	5.36		E.	8	199,000
I Means	Group 9.....	580.61	575.10	5.51				194,200
73	Oct. 28, 1899	580.62	574.76	5.86		N.W.	10	194,600
74	Oct. 28, 1899	0.63	4.76	5.87		N.	10	196,300
237	Sept. 23, 1902	0.63	5.21	5.42		N.	12	190,600
7	May 23, 1899	0.64	5.16	5.48		N.	10	201,600
15	June 7, 1899	0.64	5.36	5.28		S.	16	196,400
132	Nov. 9, 1900	0.64	4.91	5.73		N.W.	20	198,600
216	Sept. 5, 1902	0.64	5.26	5.38		N.E.	6	194,500
101	July 7, 1900	0.66	5.16	5.50		S.W.	16	191,100
19	June 13, 1899	0.68	5.36	5.32		S.	18	193,900
96	June 29, 1900	0.68	5.16	5.52		N.W.	18	192,900
J Means	Group 10....	580.65	575.11	5.54				195,000
117	Aug. 6, 1900	580.68	575.36	5.32		W.	12	192,900
207	Aug. 26, 1902	0.69	5.36	5.33		W.	7	192,600
145	Dec. 10, 1900	0.69	4.81	5.88		N.W.	16	201,800
113	Aug. 2, 1900	0.69	5.36	5.33		S.W.	10	189,200
66	Oct. 17, 1899	0.70	4.86	5.84		N.W.	7	198,700
141	Dec. 5, 1900	0.70	4.81	5.89		N.W.	16	201,100
146	Dec. 11, 1900	0.70	4.81	5.89		N.W.	20	204,500
206	Aug. 25, 1902	0.70	5.46	5.24		N.	6	194,000
223	Sept. 12, 1902	0.71	5.26	5.45		S.W.	4	195,000
56	Sept. 7, 1899	0.72	5.16	5.56		S.	12	192,500
K Means	Group 11....	580.70	575.12	5.58				196,200
198	Aug. 18, 1902	580.72	575.51	5.21		S.W.	9	193,200
215	Sept. 5, 1902	0.72	5.26	5.46		W.	7	195,400
103	July 23, 1900	0.73	5.31	5.42		S.W.	7	189,400
109	July 28, 1900	0.73	5.36	5.37		S.W.	9	193,300
128	Sept. 18, 1900	0.73	5.06	5.67		E.	9	197,000
97	June 30, 1900	0.74	5.16	5.58		N.W.	17	196,400
14	June 6, 1899	0.74	5.30	5.44		S.W.	12	203,300
143	Dec. 7, 1900	0.75	4.81	5.94		N.E.	8	202,400
232	Sept. 19, 1902	0.75	5.21	5.54		N.	12	194,800
77	Nov. 3, 1899	0.75	4.83	5.92		N.E.	17	204,900
L Means	Group 12....	580.74	575.18	5.56				197,000

Williams Ex. 21. U. S. LAKE SURVEY 4-Table

Discharge Measurements—Dry Dock Section Sheet 4

ST. CLAIR RIVER (7 Sheets)

1899-1900-1902

	No. of Meas.	Date	Water Surface		Fall	Rise+ Fall—	Wind		Discharge Cu. Ft. per Sec.
			Lake Huron	St. Clair Flats			Dir.	Vel.	
	11	June 2, 1899	580.76	575.26	5.50		N.	14	204,200
	110	July 28, 1900	0.76	5.36	5.40		S.W.	12	194,300
	202	Aug. 20, 1902	0.76	5.46	5.30		S.E.	6	196,000
	135	Nov. 15, 1900	0.77	4.86	5.91		N.W.	20	200,500
	105	July 24, 1900	0.77	5.26	5.51		N.E.	9	190,500
	134	Nov. 13, 1900	0.78	4.86	5.92		N.W.	16	203,400
	118	Aug. 8, 1900	0.79	5.26	5.53		N.W.	15	193,800
	211	Sept. 2, 1902	0.79	5.36	5.43		N.	9	197,400
	64	Oct. 14, 1899	0.80	4.86	5.94		N.W.	18	209,200
	104	July 24, 1900	0.81	5.28	5.53		N.W.	13	191,200
M	Means	Group 13....	580.78	575.18	5.60				198,000
	114	Aug. 22, 1900	580.81	575.36	5.45		S.W.	7	196,400
	119	Aug. 8, 1900	0.81	5.26	5.55		N.W.	17	192,900
	120	Aug. 27, 1900	0.81	5.26	5.55		S.W.	12	191,000
	200	Aug. 19, 1902	0.81	5.46	5.35		N.	12	196,000
	210	Aug. 28, 1902	0.81	5.36	5.45		N.E.	14	196,700
	208	Aug. 26, 1902	0.82	5.36	5.46		W.	14	194,800
	195	Aug. 14, 1902	0.82	5.61	5.21		N.E.	6	197,400
	54	Sept. 1, 1899	0.82	5.26	5.56		N.	7	201,900
	20	June 14, 1899	0.84	5.36	5.48		S.	17	194,200
	112	Aug. 1, 1900	0.85	5.36	5.49		N.E.	9	195,000
N	Means	Group 14....	580.82	575.36	5.46				195,660
	122	Sept. 4, 1900	580.85	575.26	5.59		N.E.	8	193,100
	199	Aug. 18, 1902	0.85	5.51	5.34		S.W.	11	192,200
	52	Aug. 30, 1899	0.87	5.36	5.51		S.E.	11	199,900
	60	Sept. 22, 1899	0.87	5.06	5.81		N.W.	8	204,900
	201	Aug. 19, 1902	0.87	5.46	5.41		N.E.	13	201,800
	209	Aug. 27, 1902	0.87	5.42	5.45		N.	9	198,000
	121	Sept. 4, 1900	0.88	5.26	5.62		E.	9	195,100
	126	Sept. 14, 1900	0.89	5.21	5.68		N.E.	11	196,900
	53	Aug. 31, 1899	0.91	5.36	5.55		E.	9	200,700
	16	June 8, 1899	0.91	5.36	5.55		N.W.	10	206,700
O	Means	Group 15....	580.88	575.33	5.55				198,900
	17	June 10, 1899	580.92	575.36	5.56		N.	8	205,900
	55	Sept. 6, 1899	0.94	5.16	5.78		N.	10	202,900
	196	Aug. 15, 1902	0.95	5.61	5.34		N.	6	201,200
	203	Aug. 21, 1902	0.95	5.46	5.49		N.E.	12	202,000
	106	July 25, 1900	0.96	5.31	5.65		N.	18	197,900
	50	Aug. 28, 1899	0.96	5.36	5.60		N.	13	206,900
	21	June 15, 1899	0.96	5.36	5.60		N.W.	13	202,300
	111	July 31, 1900	0.96	5.36	5.60		N.W.	12	199,300
	193	Aug. 12, 1902	0.96	5.66	5.30		N.E.	11	199,500
	49	Aug. 24, 1899	0.97	5.36	5.61		S.	10	200,300
P	Means	Group 16....	580.95	575.40	5.55				201,900

Williams Ex. 21

5-Table Sheet 5 (7 Sheets)

U. S. LAKE SURVEY
Discharge Measurements—Dry Dock Section
ST. CLAIR RIVER
1899-1900-1902

	No. of Meas.	Date	Water Surface		Fall	Rise+ Fall-	Wind		Discharge Cu. Ft. per Sec.
			Lake Huron	St. Clair Flats			Dir.	Vel.	
	31	Aug. 29, 1899	580.98	575.36	5.62		E.	10	204,100
	214	Sept. 4, 1902	580.99	5.26	5.73		N.W.	22	209,600
	75	Nov. 1, 1899	581.00	4.86	6.14		N.	19	207,200
	204	Aug. 21, 1902	1.00	5.46	5.54		N.E.	12	201,500
	197	Aug. 16, 1902	1.00	5.51	5.49		N.E.	13	200,400
	194	Aug. 13, 1902	1.01	5.66	5.35		S.E.	8	194,400
	107	July 26, 1900	1.02	5.31	5.71		N.E.	10	200,900
	23	June 17, 1899	1.02	5.36	5.66		N.	8	205,100
	57	Sept. 8, 1899	1.02	5.16	5.86		N.W.	5	206,400
	58	Sept. 9, 1899	1.02	5.16	5.86		N.W.	8	204,300
Q	Means	Group 17....	581.01	575.31	5.70				203,400
	59	Sept. 14, 1899	581.04	575.16	5.88		S.E.	8	205,900
	108	July 26, 1900	1.04	5.31	5.73		N.E.	16	199,100
	147	Dec. 13, 1900	1.06	4.76	6.30		N.W.	25	214,100
	76	Nov. 1, 1899	1.07	4.86	6.21		N.	19	212,500
	46	Aug. 16, 1899	1.08	5.36	5.72		N.	10	205,400
	35	July 26, 1899	1.08	5.56	5.52		S.	12	196,700
	205	Aug. 22, 1902	1.08	5.46	5.62		N.W.	16	207,500
	31	July 20, 1899	1.09	5.55	5.54		S.E.	14	203,900
	27	July 15, 1899	1.09	5.56	5.53		S.E.	10	205,300
	213	Sept. 4, 1902	1.09	5.26	5.83		N.W.	20	213,500
R	Means	Group 18....	581.07	575.28	5.79				206,400
	43	Aug. 12, 1899	581.11	575.51	5.60		S.W.	17	203,100
	44	Aug. 14, 1899	1.11	5.46	5.65		N.	15	210,500
	48	Aug. 23, 1899	1.11	5.36	5.75		N.W.	10	206,700
	45	Aug. 15, 1899	1.12	5.46	5.66		N.	15	210,900
	22	June 16, 1899	1.13	5.36	5.77		N.W.	12	210,800
	33	July 24, 1899	1.14	5.56	5.58		N.	9	206,000
	125	Sept. 12, 1900	1.14	5.28	5.86		N.W.	20	200,600
	26	July 12, 1899	1.15	5.51	5.64		N.	12	211,800
	34	July 25, 1899	1.15	5.56	5.59		N.W.	9	206,800
	42	Aug. 8, 1899	1.16	5.56	5.60		N.	10	208,300
S	Means	Group 19....	581.13	575.46	5.67				207,600
	38	July 29, 1899	581.18	575.56	5.62		S.	18	206,200
	24	July 29, 1899	1.18	5.46	5.72		S.W.	10	207,100
	37	July 28, 1899	1.19	5.56	5.63		S.W.	9	205,300
	29	July 18, 1899	1.19	5.56	5.63		N.W.	13	206,800
	30	Aug. 3, 1899	1.18	5.56	5.62		S.	6	206,300
	40	Aug. 5, 1899	1.21	5.56	5.65		W.	6	205,000
	41	Aug. 7, 1899	1.22	5.56	5.66		N.	10	209,900
	32	July 22, 1899	1.22	5.56	5.66		N.W.	12	210,900
	25	July 11, 1899	1.25	5.51	5.74		W.	10	210,600
	30	July 19, 1899	1.28	5.56	5.72		N.W.	10	207,200
T	Means	Group 20....	581.21	575.54	5.67				207,800
	127	Sept. 17, 1900	581.29	575.08	6.21		N.W.	25	209,000
	36	July 27, 1899	1.33	5.56	5.77		N.E.	10	209,300
	47	Aug. 27, 1899	1.33	5.36	5.97		N.W.	12	217,400
	28	July 17, 1899	1.39	5.56	5.83		N.W.	15	218,900
U	Means	Group 21....	581.34	575.39	5.95				213,600

Williams Ex. 21.

U. S. LAKE SURVEY

Discharge Measurements—Dry Dock Section

ST. CLAIR RIVER

1901

A-Table Sheet 6 (7 Sheets)

No. of Meas.	Date	Water Surface		Fall	Rise + Fall —	Wind		Discharge Cu. Ft. per Sec.
		Lake Huron	St. Clair Flats			Dir.	Vel.	
164	May 22, 1901	580.37	574.76	5.61		S.W.	20	193,300
165	May 22, 1901	0.41	4.76	5.65		S.W.	20	194,600
182	June 11, 1901	0.62	4.96	5.66		S.W.	12	200,500
166	May 23, 1901	0.73	4.76	5.97		S.W.	10	203,500
167	May 23, 1901	0.77	4.76	6.01		S.W.	14	202,500
159	May 17, 1901	0.78	4.56	6.22		S.W.	7	206,000
157	May 14, 1901	0.79	4.54	6.25		N.E.	12	211,200
180	June 22, 1901	0.81	5.06	5.75		S.W.	14	201,600
174	June 4, 1901	0.82	4.96	5.86		S.W.	10	204,600
158	May 15, 1901	0.82	4.54	6.28		N.	12	210,700
Means	Group 1-01	580.69	574.77	5.92				202,800
181	June 11, 1901	580.83	574.96	5.87		W.	6	208,100
180	June 10, 1901	0.85	4.96	5.89		S.W.	12	202,200
160	May 18, 1901	0.86	4.61	6.25		N.	20	213,500
183	June 13, 1901	0.86	4.96	5.90		N.E.	7	205,100
187	June 17, 1901	0.88	5.01	5.87		E.	7	202,300
162	May 20, 1901	0.89	4.84	6.05		N.E.	10	210,000
161	May 20, 1901	0.89	4.79	6.10		N.E.	12	212,400
192	June 28, 1901	0.90	5.16	5.74		S.W.	18	198,900
163	May 21, 1901	0.90	4.81	6.09		E.	12	213,000
184	June 14, 1901	0.92	4.96	5.96		N.E.	5	209,100
Means	Group 2-01	580.88	574.91	4.97				207,700
179	June 10, 1901	580.92	574.96	5.96		S.W.	10	207,900
185	June 14, 1901	0.92	4.96	5.96		N.E.	12	206,600
188	June 20, 1901	0.92	5.06	5.86		E.	5	201,800
186	June 15, 1901	0.93	5.04	5.89		N.E.	15	208,900
173	June 3, 1901	0.95	4.96	5.99		N.W.	5	211,000
191	June 27, 1901	0.95	5.16	5.79		S.W.	9	206,400
190	June 26, 1901	581.02	5.11	5.91		S.W.	12	205,800
172	May 29, 1901	1.04	4.86	6.18		N.	11	211,000
171	May 28, 1901	1.08	4.96	6.12		N.	25	231,800
170	May 28, 1901	1.11	4.86	6.25		N.	20	210,400
Means	Group 3-01	580.98	574.98	6.00				209,000
178	June 8, 1901	581.11	574.96	6.15		N.E.	10	218,500
175	June 7, 1901	1.13	4.96	6.17		W.	20	208,800
176	June 7, 1901	1.14	4.96	6.18		W.	20	211,300
165	May 24, 1901	1.17	4.76	6.41		N.W.	15	216,100
169	May 25, 1901	1.19	4.76	6.43		N.	28	220,700
177	June 8, 1901	1.24	4.96	6.28		N.W.	12	215,100
Means	Group 4-01	581.16	574.89	6.27				213,400

Group	Meas. Disc.	Comp. Disc.
1-01 (V)	202,800	196,200
2-01 (W)	207,700	201,300
3-01 (X)	209,000	202,500
4-01 (Y)	213,400	203,700

Discharge was decreased by ¼ of 1 per cent for each tenth foot Lake St. Clair was below normal, as expressed by equation St. Clair = 574.79 + 0.60 (Harbor Beach — 580).

Elevations of St. Clair have not been corrected for adjustment of December, 1903, which increased elevations 0.06 feet.

Williams Ex. 21.

U. S. LAKE SURVEY

Discharge Measurements—Dry Dock Section

ST. CLAIR RIVER

1908

Table

Sheet 7
(7 Sheets)

No. of Meas.	Date	Water Surface		Fall	Rise + Fall −	Wind		Discharge Cu. Ft. per Sec.
		Lake Huron	St. Clair Flats			Dir.	Vel.	
0813	Dec. 14, 1908	579.90	575.03	4.87		S.E.	8	167,950
0814	Dec. 14, 1908	579.94	4.99	4.95		S E.	8	173,270
0812	Nov. 23, 1908	580.03	5.09	4.94		S.E.	2-20	178,300
0815	Dec. 18, 1908	0.11	4.92	5.19		N.W.	25	181,520
0811	Nov. 21, 1908	0.23	5.10	5.13		S.E.	8	189,680
083	Nov. 7, 1908	0.48	5.37	5.11		W.	20	166,930
080	Nov. 11, 1908	0.48	5.28	5.20		N.W.	6	191,870
I Means	Group 1-08.	580.17	575.11	5.06				182,500
0810	Nov. 11, 1908	580.51	575.31	5.20		N.W.	18	195,090
088	Nov. 10, 1908	0.52	5.31	5.21		S.W.	4	190,160
086	Nov. 10, 1908	0.56	5.32	5.24		N.E.	2	191,160
08	Nov. 10, 1908	0.60	5.32	5.28		N.E.	2	192,570
084	Nov. 9, 1908	0.61	5.37	5.24		S.W.	30	191,380
081	Nov. 7, 1908	0.62	5.38	5.24		S.W.	20	190,420
085	Nov. 9, 1908	0.67	5.37	5.30		S.W.	20	197,460
072	Nov. 7, 1908	0.69	5.38	5.31		S.W.	25	187,760
X Means	Group 2-08.	580.59	575.34	5.25				191,000

TABLE B. U.S. LAKE SURVEY Sheet 1 (6 Sheets)
Williams Ex. 22 HYDRAULICS OF ST. CLAIR RIVER
MEAN SLOPE
FOR PERIOD NOVEMBER-DECEMBER 1908

SIDNEY MOORE, Asst. Engr.
APRIL, 1909.

GAGES	Miles from Ft. Gratiot Lighthouse	Differences of Distances	Mean Elevation Nov.-Dec. 1908	Differences of Elevation	Fall from Ft. Gratiot L.H.
Harbor Beach	53.		584.38		
		17.6		0.12	
Huronia Beach	1.36		584.26		
		1.36		0.07	
Ft. Gratiot L.H.	0.00		584.19		0.00
		0.26		0.63	
Sect. on Gorge	0.26		583.56		0.63
		0.08		0.24	
Section Gage (1908)	0.34		583.32		0.87
		0.46		-0.20	
G.T.R.	0.80		583.52		0.67
		1.57		0.41	
Mouth of Black River	2.37		583.11		1.08
		2.53		0.42	
Dry Dock (Dunford)	4.90		582.69		1.50
		2.10		0.45	
Roberts Landing	26.9		582.24		1.95
		13.8		0.10	
St. Clair Flats Canal	38.8		582.14		2.05

Williams Ex. 22

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Summary of Discharge Measurements
Section Gorge

Sheet 2
(6 Sheets)
Table 5
Sherman Moore, Jun. Engr.
April, 1906

No.	Date 1906	Water Surface Elevations				Fall		Change at Lake		Wind		Volume of Discharge					Weighted Mean Index Velocity
		Fort Gratiot	G.T.R.	Dry Dock	St. Clair Flats	Ft. G. G.T.R.	G.T.R. D.D.	Rise	Fall	Dir.	Vel. miles	46A	1B	14B	15B	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S
1	Nov. 18	580.58	579.62	578.75	573.07	0.96	0.87	0.10	0.01	W.N.W.	20		195,660			195,660	6.49
2	Nov. 27	580.35	579.73	578.87	573.10	0.62	0.85	0.05	0.25	S.W.	40		190,230	180,040		185,130	6.14
3	Nov. 27	580.53	579.68	578.96	573.11	0.85	0.88	0.09	0.22	S.W.	25		196,830	192,960		194,400	6.42
4	Nov. 26	579.90	579.29	578.53	573.12	0.61	0.80	0.14	0.13	S.W.	20	172,660	175,570			174,700	5.85
5	Nov. 26	580.06	579.45	578.66	573.13	0.61	0.79	0.20	0.17	S.	18		178,640	176,750		177,700	5.91
6	Dec. 1	580.49	579.84	579.01	573.11	0.65	0.83	0.06	0.02	S.W.	35		195,470	191,090		193,280	6.38
7	Dec. 2	580.75	580.04	579.13	573.11	0.71	0.91	0.09	0.05	W.S.W.	20	203,710		200,110		201,910	6.63
8	Dec. 3	580.67	579.95	579.11	573.12	0.72	0.87	0.07	0.13	W.S.W.	20	190,250		194,540		196,900	6.48
9	Dec. 4	580.37	579.70	578.84	573.07	0.67	0.86	0.20	0.24	S.W.	16		189,360		189,800	189,580	6.27
10	Dec. 9	580.38	579.68	578.72	574.98	0.70	0.96	0.24	0.35	W.	10		188,270		201,000	188,270	6.27
11	Dec. 9	580.11	579.40	578.63	574.94	0.65	0.83	0.13	0.14	N.W.	8		185,230		194,220	185,230	6.19
12	Dec. 10	579.96	579.23	578.48	574.96	0.65	0.82	0.09	0.19	S.E.	3		183,570	182,910		183,240	6.13
13	Dec. 10	580.00	579.34	578.58	574.97	0.66	0.81	0.14	0.20	S.E.	12		180,090	181,640		180,860	6.05
14	Dec. 11	579.93	579.31	578.46	574.89	0.62	0.83	0.26	0.26	W.	4	180,510		181,900		181,200	6.06
15	Dec. 12	580.03	579.30	578.57	574.96	0.64	0.82	0.41	0.32	S.W.	12	181,060			192,570	181,060	6.03
16	Dec. 12	580.11	579.46	578.67	574.97	0.65	0.81	0.01	0.40	S.W.	15	178,040			191,430	178,040	6.09
17	Dec. 15	580.11	579.44	578.60	574.94	0.67	0.84	0.19	0.19	S.W.	8			184,060	197,260	184,060	6.16
18	Dec. 16	580.08	579.41	578.39	574.92	0.67	0.83	0.12	0.08	N.W.	4	188,730	182,860			185,680	6.19
19	Dec. 16	580.10	579.42	578.37	574.92	0.68	0.85	0.04	0.12	N.W.	2	191,040	183,730			187,400	6.25
20	Dec. 17	580.06	579.33	578.46	574.98	0.73	0.85	0.16	0.20	N.E.	13	192,430			198,740	192,430	6.45
21	Dec. 18	579.77	579.13	578.20	575.06	0.64	0.79	0.33	0.33	S.S.W.	35		166,400	174,510		170,460	5.74
22	Dec. 19	579.77	579.17	578.42	575.10	0.60	0.75	0.47	0.17	S.W.	10		166,100	170,860		168,480	5.66

Williams Exhibit 22.

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Summary of Discharge Measurements
Section Dry Dock

Sheet 1
(6 Sheets)
Table 7
Sherman Moore, Jun. Engr.
April, 1909

Number	Date 1908	Water Surface Elevations				Fall		Change at Lake		Wind		VOLUME OF DISCHARGE (cubic feet per second)				
		Pipe Grates	G.T.R.	Dry Dock	St. Clair Flats	Ft. G. G.T.R.	G.T.R. D.D.	Rise	Fall	Dir.	Vel. Miles	44A	1B	14B	16B	Adopted
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R
8801	Nov. 1	580.46	579.51	579.60	578.36	0.88	0.91	0.01	0.11	S.W.	20		190,940	189,000		190,420
8802	Nov. 2	580.51	579.58	579.67	578.36	0.92	0.91	0.02	0.11	S.W.	22		189,270	186,240		187,760
8803	Nov. 7	580.39	579.60	579.64	578.37	0.94	0.92	0.08	0.10	W	20		187,860	184,000		186,930
8804	Nov. 8	580.43	579.70	579.76	578.37	0.89	0.86	0.13	0.26	S.W.	28	188,720			189,000	191,360
8805	Nov. 9	580.49	579.72	579.87	578.37	0.87	0.85	0.16	0.28	S.W.	30	195,040			190,870	197,600
8806	Nov. 10	580.38	579.76	579.84	578.33	0.89	0.88	0.04	0.32	N.E.	3	189,780		189,540		191,140
8807	Nov. 10	580.43	579.73	579.80	578.33	0.90	0.87	0.15	0.11	N.E.	7	192,460		189,540		192,570
8808	Nov. 10	580.34	579.68	579.76	578.31	0.89	0.87	0.04	0.79	S.W.	4	188,200	191,120			190,160
8809	Nov. 11	580.30	579.69	579.69	578.31	0.84	0.84	0.16	0.14	N.W.	6		189,812		189,000	191,570
8810	Nov. 11	580.33	579.67	579.84	578.31	0.86	0.83	0.06	0.15	N.W.	16		192,540		187,440	189,060
8811	Nov. 21	580.42	579.69	579.84	578.30	0.82	0.86	0.19	0.22	S.E.	6		188,610		189,780	188,880
8812	Nov. 20	579.85	579.24	579.41	578.08	0.61	0.82	0.10	0.30	S.E.	3-20		179,020	176,970		178,200
8813	Dec. 14	579.72	579.14	579.30	578.08	0.64	0.78	0.05	0.20	S.E.	6		177,660		179,280	177,990
8814	Dec. 14	579.78	579.17	579.30	578.09	0.60	0.78	0.02	0.14	S.E.	6		178,270		183,510	179,370
8815	Dec. 15	579.98	579.30	579.51	578.09	0.68	0.79	0.12	0.09	N.W.	28		179,780	180,280		181,530
	Mean....	580.13			578.34											187,980

Williams Exhibit 22.

108

HYDRAULICS OF ST. CLAIR RIVER.
Discharge of St. Clair River.
Section "George."

(1) Sheet 1
Table 2 (a)
Sherman Moore, Jun. Engr.
March, 1920

Number	Date	Water Section Elevations				Fall		Change at Lake		Wind		Ratings				Volume of Discharge (cubic ft. per sec.)					Weighted Mean Index Velocity
		First Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to D.D.	Rise	Fall	Dir.	Vel. Miles	1B	14B	15B	46A	1B	14B	15B	46A	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	1908																				
2	Nov. 15	580.11	579.69	579.71	579.07	0.99	0.91	0.10	0.01	W.N.W.	30	10				192,850				192,900	6.43
3	27	580.25	579.73	579.89	579.10	0.52	0.89	0.06	0.26	S.W.	40	10	12			188,570	176,710			188,900	6.14
4	28	579.90	579.32	579.48	578.18	0.58	0.84	0.14	0.13	S.W.	20	10	12			194,250	191,410			192,800	6.43
5	30	580.06	579.45	579.63	578.13	0.61	0.82	0.54	0.34	S.	12	10			11	175,240			171,170	173,200	6.86
6	Dec. 1	*580.53	579.84	579.97	578.11	*0.69	0.27	0.09	0.02	S.W.	25	10	12			176,970	174,990			176,000	5.91
7	2	580.75	580.04	579.09	578.11	0.71	0.98	0.10	0.05	W.S.W.	30		12				180,440			180,400	5.85
8	3	580.07	579.36	579.07	578.13	0.71	0.23	0.07	0.10	W.S.W.	30		12		11		198,760		201,980	200,400	6.62
9	4	580.37	579.76	579.80	578.07	0.61	0.91	0.07	0.10	W.S.W.	30		12		11		193,250		197,500	195,400	6.46
10	9	580.28	579.16	579.86	578.06	0.72	0.90	0.28	0.19	S.W.	16	11		12		187,690		198,170		187,700	5.27
11	9	580.11	579.46	579.59	578.04	0.65	0.87	0.13	0.13	W.	10	11		12		188,750		199,260		186,850	5.27
12	10	579.96	579.26	579.44	578.06	0.70	0.86	0.10	0.13	N.W.	8	11		12		183,670		193,520		188,700	5.19
13	11	580.09	579.34	579.49	578.07	0.75	0.85	0.14	0.10	S.E.	3	11	12			181,990	181,280			181,630	5.13
14	11	579.95	579.21	579.44	578.09	0.74	0.87	0.14	0.17	S.E.	12	11	12			178,540	179,980			179,300	5.06
15	12	580.03	579.30	579.52	578.06	0.73	0.88	0.20	0.06	W.	4				11		180,810		178,980	179,600	4.98
16	13	580.11	579.43	579.62	578.07	0.68	0.86	0.41	0.36	S.W.	13			12	11			190,680	179,980	179,800	5.08
17	15	580.11	579.44	579.66	578.04	0.67	0.88	0.01	0.40	S.W.	15			12	11			189,910	181,290	181,200	5.09
18	16	580.08	579.41	579.65	578.05	0.67	0.88	0.19	0.19	S.W.	8		12	12			182,500	186,620		183,500	5.16
19	16	580.10	579.42	579.53	578.02	0.68	0.89	0.13	0.09	N.W.	4	11			11	190,770			187,120	182,900	5.19
20	17	580.06	579.35	579.46	578.04	0.71	0.89	0.04	0.13	N.W.	2	11			11	182,190			189,530	185,900	5.25
21	18	579.97	579.16	579.36	578.03	0.81	0.80	0.13	0.20	N.E.	8-16			12	11			197,220	191,040	191,000	5.48
22	19	579.77	579.17	579.36	578.10	0.60	0.79	0.47	0.17	S.W.	10	11	12			164,780	172,840			168,800	5.74
												11	12			164,740	169,420			167,100	5.66
												16B	14B	15B	Price	16B	14B	15B	Price		
23	1908																				
24	Oct. 13	580.32	579.97	579.93	578.20	0.65	0.84	0.22	0.29	W.	15	H	G			186,260	188,800			186,000	6.23
25	14	580.18	579.82	579.90	578.25	0.70	0.83	0.06	0.15	W.	15	H		X		188,710		191,220		190,000	6.37
26	15	580.47	579.75	579.93	578.24	0.72	0.82	0.05	0.13	W.N.W.	18-30	H		X		184,570		189,610		187,100	6.19
27	16	580.49	579.71	579.86	578.23	0.78	0.85	0.03	0.05	W.N.W.	28	H		X		182,330		188,550		185,400	6.13
28	16	580.41	579.65	579.84	578.24	0.76	0.89	0.05	0.11	W.N.W.	20	H		X		191,740		193,750		192,700	6.34
29	26	579.76	579.20	579.41	578.21	0.56	0.79	0.19	0.19	S.W.	15	H		X		170,060		167,850		169,000	5.67
30	26	579.88	579.27	579.41	578.23	0.61	0.86	0.24	0.00	S.W.	15	H		X		171,000		166,800		169,900	5.72
31	27	580.25	579.80	579.73	578.21	0.45	0.87	0.13	0.14	W.	8	H	G			186,790	188,030			187,900	6.22
32	27	580.23	579.99	579.82	578.20	0.53	0.87	0.26	0.07	W.	20	H	G			191,040	193,960			192,500	6.33
33	27	580.25	579.95	579.82	578.21	0.60	0.83	0.04	0.26	W.	20	H	G			187,670	189,030			188,400	6.24
34	28	580.14	579.48	579.61	578.14	0.62	0.87	0.06	0.12	W.	10	H	G			190,230	189,270			189,800	6.34
35	Nov. 1	579.73	579.10	*579.30	*578.12	0.63	*0.90	0.09	0.06	S.E.	8	H	G			185,460	182,910			184,700	6.16
														X			178,630	177,190		177,900	6.01

*Elevations interpolated.

Williams Ex. 22.

Williams Ex. 22.

U. S. LAKE SURVEY.
HYDRAULICS OF ST. CLAIR RIVER.
Discharge of St. Clair River.
Section Gorge.

Sheet 5
(6 Sheets)
Table 2, p. 2
Sherman Moore, Jun. Eng.
March, 1910

Number	Date	Water Surface Elevations				Fall		Change at Lake		Wind		Ratings				Volume of Discharge (cu. ft. per sec.)					Weighted Mean Index Velocity
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to D.D.	Rise	Fall	Dir.	Vel. Miles	10B	14B	15B	Price	10B	14B	15B	Price	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
36	1909																				
37	Nov. 1	579.78	579.15	*578.26	*575.11	0.63	*0.89	0.16	0.12	S.E.	7		G	X			174,740	176,580		175,700	5.92
38	4	580.23	579.61	578.74	575.00	0.71	0.87	0.27	0.15	W.	6			X	F			194,280	199,700	194,900	6.47
39	5	580.02	579.34	578.51	575.00	0.68	0.83	0.04	0.09	W.	6	H			F	184,570			190,630	184,600	6.18
40	5	579.98	579.29	578.50	575.02	0.69	0.79	0.21	0.21	W.	6	H			F	183,380			186,860	183,400	6.16
41	8	580.00	579.36	578.48	575.00	0.73	0.88	0.41	0.04	S.W.	4	H				182,886				182,900	6.13
42	8	579.99	579.31	578.55	575.02	0.68	0.76	0.09	0.3	S.	4	H				177,850				177,800	5.96
43	6	580.01	579.33	578.48	575.02	0.69	0.82	0.23	0.09	N.E.	8	H		X		180,060		181,570		181,000	6.06
44	6	579.97	579.28	578.50	575.00	0.69	0.78	0.07	0.13	N.E.	8	H		X		180,410		181,210		180,800	6.07
45	6	580.00	579.29	578.48	575.00	0.71	0.83	0.11	0.12	N.E.	8	H		X		182,760		183,560		183,700	6.17
46	6	579.97	579.24	578.42	575.10	0.73	0.82	0.09	0.15	N.E.	8	H				180,630				180,600	6.06
47	10	579.88	579.85	*578.02	575.08	0.63	*0.93	0.07	0.07	S.E.	5			X	F			168,950	169,530	169,000	5.72
48	10	579.76	579.07	*578.03	575.08	0.69	*1.04	0.17	0.02	S.E.	5			X	F			174,480	173,460	174,500	5.89
49	13	*579.68	579.07	*578.21	575.06	*0.61	*0.86	0.10	0.25	S.E.	6	H		X		173,420		177,010		175,200	5.91
50	Dec. 2	579.66	579.07	578.25	575.11	0.61	0.82	0.06	0.07	N.E.	10	H	G			176,210	180,170			178,200	6.02
51	2	579.69	579.09	578.29	575.10	0.60	0.80	0.11	0.01	N.E.	10	H	G			174,180	179,550			174,300	5.96
52	2	579.78	579.13	578.33	575.11	0.65	0.80	0.09	0.08	N.E.	6	H	G			174,950	180,230			175,000	5.96
53	2	579.76	579.14	578.34	575.12	0.62	0.80	0.07	0.12	N.E.	6	H	G			176,040	182,180			176,000	6.03
54	2	579.89	579.17	*578.39	575.06	0.72	*0.88	0.13	0.10	NE.-SE	2-2		G	H			184,640	178,640		178,600	6.10
55	4	579.76	579.14	*578.27	575.06	0.62	*0.87	0.24	0.10	SE-SW.	2-2		G	H			181,620	173,340		175,200	6.00
56	4	579.71	579.11	*578.28	575.07	0.60	*0.83	0.22	0.06	S.E.	2		G	H			172,780	171,870		172,200	5.89
57	6	579.50	578.90	578.26	575.06	0.51	0.73	0.21	0.11	S.W.	3-0	H	G			158,120	164,040			161,100	5.45
58	6	579.84	579.25	578.43	575.07	0.59	0.82	0.48	0.20	S.W.	15		G				179,000			179,000	5.99
59	9	580.05	579.45	*578.70	575.15	0.60	*0.75	0.24	0.11	S.W.	15		G	H			178,830	171,090		174,900	5.83
60	10	580.16	579.53	*578.73	575.11	0.63	*0.80	0.05	0.12	S.W.	15	H	G			188,220	185,600			186,900	6.21
61	10	580.21	579.56	*578.72	575.09	0.65	*0.84	0.11	0.31	W.	15	H	G			189,780	187,970			188,900	6.27

*Elevations interpolated.

HYDRAULICS OF RIVERS. Appendix 2.
Discharge of St. Clair River (6 Sheets) Table 6.
Section Dry Dock Sherman Moore, Jun. Engr.
March, 1910

Number	Date	Water Surface Elevations				Fall		Change in Lake		Wind		Ratings					Volume of Discharge (Cubic feet per second)					
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to Dry Dock	Rise	Fall	Dir.	Vel. Miles	46A	1B	14B	15B		46A	1B	14B	15B		Adopted
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	1908																					
09- 1	Nov. 7	*580.48	579.61	578.96	575.36	0.68	0.85	0.31	0.11	S.W.	20		10	12				190,940	189,900				
09- 2	7	*580.44	579.53	578.93	575.36	0.71	0.90	0.02	0.31	S.W.	25		10	12				188,270	186,280				190,400
09- 3	7	*580.33	579.46	578.80	575.37	0.67	0.86	0.06	0.10	W.	20		10	12				187,860	186,000				187,800
09- 4	9	*580.45	579.75	578.85	*575.37	0.70	0.90	0.12	0.26	S.W.	30	11			12		188,720			193,930			190,900
09- 5	9	*580.52	579.82	578.93	*575.37	0.70	0.89	0.16	0.08	S.W.	20	11			12		196,040			190,870			191,400
09- 6	10	*580.39	579.70	578.80	*575.32	0.69	0.90	0.04	0.13	N.E.	2	11		12			189,790		192,540				197,500
09- 7	10	*580.43	579.73	578.83	*575.32	0.70	0.91	0.15	0.11	N.E.	2	11		12			192,490		192,580				191,200
09- 8	10	*580.34	579.65	578.74	*575.31	0.69	0.91	0.04	0.19	S.W.	4	11	10				189,200	191,120					192,600
09- 9	11	*580.34	579.66	578.78	*575.25	0.68	0.88	0.15	0.14	N.W.	6		10		12			188,810					190,300
09-10	11	*580.34	579.67	578.80	*575.31	0.67	0.87	0.08	0.15	N.W.	15		10		12			192,540		193,930			191,900
09-11	21	*580.05	579.40	578.50	*575.10	0.65	0.90	0.19	0.23	S.E.	8		10		12			189,610		197,940			195,100
09-12	23	579.85	579.24	578.37	*575.09	0.61	0.87	0.10	0.28	S.E.	2-20		10	12				179,620	176,870	189,760			189,700
09-13	Dec. 14	579.72	579.14	578.32	575.03	0.58	0.82	0.05	0.20	S.E.	8		10		12			167,950		179,380			178,300
09-14	14	579.76	579.17	578.35	574.99	0.59	0.82	0.22	0.14	S.E.	8		11		12			173,270		183,520			168,000
09-15	18	579.63	579.30	578.47	*574.92	0.62	0.83	0.12	0.29	N.W.	25		11	12				179,750	183,280				173,300
																							181,500
												267	268	14B	15B	10B	267	268	14B	15B	10B	
09- 1	Nov. 15	580.24	579.56	578.65	575.05	0.66	0.91	0.24	0.20	S.W.	15	G				H	197,430				193,740	193,700
09- 2	15	580.26	579.66	578.78	575.03	0.70	0.90	0.07	0.35	W.	5	G				H	200,860				190,130	190,100
09- 3	16	579.92	579.32	578.40	575.17	0.66	0.83	0.26	0.26	N.E.	12-30		G	G				190,950	187,660				187,600
09- 4	16	579.66	579.02	578.22	575.13	0.54	0.80	0.30	0.50	E.-S.E.	12		G	G				172,480	170,550				171,000
09- 5	19	579.78	579.19	578.30	575.10	0.59	0.80	0.15	0.16	S.E.	18	G			H		185,420			176,520			176,600
09- 6	19	579.80	579.22	578.41	575.09	0.58	0.81	0.12	0.23	S.E.	20	G			H		187,750			183,760			183,800
09- 7	20	579.42	578.91	578.16	575.08	0.53	0.75	0.36	0.42	S.E.	25-35		G			H		181,170			163,200		163,200
09- 8	20	579.80	579.22	578.35	574.98	0.58	0.87	0.53	0.18	S.E.-S.W.	35-10		G			H		180,700			178,470		178,500
09- 9	22	580.23	579.57	578.70	575.21	0.66	0.87	0.34	0.47	N.W.	10-18	G		G			203,300		202,270				203,300
09-10	22	580.18	579.50	578.64	575.25	0.65	0.86	0.13	0.27	N.W.	18	G		G			197,270		197,280				197,300
09-11	24	579.95	579.30	578.33	575.26	0.65	0.92	0.09	0.29	N.E.	4		G		H			190,940		189,460			189,500
09-12	24	579.80	579.20	578.39	575.25	0.60	0.81	0.29	0.25	N.E.	4		G		H			185,220		184,180			184,200
09-13	26	579.84	579.27	578.50	575.21	0.57	0.77	0.16	0.14	N.E.	2				H	I				180,270	178,990		179,000
09-14	26	579.85	579.27	578.44	575.20	0.58	0.83	0.34	0.35	S.E.	2			I	H				182,830	179,660			181,900
09-15	27	579.45	578.90	578.12	575.16	0.55	0.78	0.35	0.31	S.E.	10-20			I		H			168,930		169,980		169,400
09-16	27	579.44	578.95	578.18	575.14	0.50	0.77	0.33	0.17	S.E.	18			I		H			167,840		169,200		168,500
09-17	27	579.63	579.06	578.26	575.14	0.57	0.80	0.20	0.36	S.E.-S.W.	18-8			G		I			170,310		169,010		169,700
09-18	28	580.05	579.40	578.55	575.09	0.65	0.85	0.33	0.44	N.W.	15	G	G				194,200	194,200					
09-19	29	579.97	579.35	578.50	575.13	0.62	0.85	0.25	0.12	N.	12-0	G	G				195,450	196,550					
09-20	29	579.83	579.24	578.44	575.15	0.59	0.80	0.24	0.29	N.W.	12	G	G				188,780	186,870					
09-21	30	579.79	579.17	578.36	575.12	0.62	0.81	0.22	0.25	N.E.	0	G				I	181,050				176,130		176,100
09-22	30	579.82	579.18	578.38	575.12	0.64	0.80	0.27	0.15	E.	0	G				I	183,360				178,720		178,700
09-23	30	579.90	579.27	578.44	575.11	0.63	0.83	0.31	0.28	E.	0	G				I	182,490				178,710		178,700
09-24	Dec. 7	580.18	579.53	578.63	575.14	0.65	0.91	0.76	0.84	S.W.	12-60	G			I		190,200			190,880			190,900

*Elevations Interpolated.

Williams Exhibit 22.

111

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Daily Mean Water Surface Elevations—Adjusted Levels of 1903

May 1910	Harbor Beach	Fort Gratiot (Shore)	Section Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
A	B	C	D	E	F	G	H	I	K	L	M	N
1	580.29	580.11	579.68	579.51	.....	578.70	577.84	576.77	576.36	575.91	575.60	575.07
2	580.42	580.26	579.79	579.72	.....	578.88	577.71	576.80	576.45	575.99	575.87	575.62
3	580.41	580.53	.....	579.85	.....	579.00	577.94	577.01	576.57	576.11	575.94	575.74
4	580.43	580.35	.....	579.75	*579.25	578.98	577.81	577.03	576.61	576.16	576.05	575.84
5	580.40	580.28	.....	579.66	*579.26	578.96	577.76	576.99	576.60	576.19	576.04	575.80
6	580.40	580.21	*579.67	*579.63	*579.20	578.84	577.73	576.96	576.57	576.15	576.02	575.82
7	580.28	580.17	579.67	579.57	579.20	578.81	577.86	576.92	576.51	576.10	575.99	575.77
8	580.21	580.10	579.58	579.50	579.13	578.74	577.63	576.87	576.47	576.06	575.96	575.71
9	580.34	580.14	579.68	579.55	*579.11	578.76	577.64	576.88	576.47	576.04	575.98	575.70
10	580.42	580.22	579.69	579.58	579.22	578.81	577.66	576.89	576.47	576.03	575.98	575.67
11	580.42	580.28	579.75	579.64	579.23	578.82	577.69	576.91	576.38	575.96	575.75	575.80
12	580.50	580.35	579.78	579.68	579.28	578.86	577.68	576.83	576.40	575.94	575.78	575.66
13	580.43	580.38	579.81	579.71	579.30	578.88	*577.64	576.82	576.39	575.92	575.77	575.66
14	580.33	580.16	579.62	579.52	579.13	578.73	577.55	576.78	576.33	575.90	575.79	575.62
15	580.34	580.09	579.55	579.44	*579.08	578.65	577.50	576.73	576.33	575.86	575.81	575.64
16	580.29	579.97	579.47	579.40	*579.02	578.60	577.45	576.68	576.29	575.87	575.78	575.64
17	580.12	*579.66	579.33	579.22	.....	578.50	577.43	576.73	576.35	575.88	575.90	575.59
18	580.45	580.19	579.69	579.59	.....	578.80	577.65	576.89	576.47	576.02	575.93	575.64
19	580.35	580.12	579.60	579.51	*579.10	578.71	577.53	576.74	576.34	575.89	575.80	575.53
20	580.36	580.02	579.58	579.44	*578.90	578.63	577.46	576.71	576.31	575.86	575.79	575.66
21	580.36	580.16	579.68	579.54	*579.15	578.73	577.56	576.75	576.34	575.90	575.79	575.53
22	580.34	580.10	579.66	579.55	*579.10	578.70	577.53	576.77	576.35	575.92	575.82	575.59
23	580.44	580.14	579.68	579.53	*579.19	578.77	577.62	576.85	576.44	576.01	575.98	575.65
24	580.51	580.25	579.74	579.62	.....	578.84	577.66	576.88	576.45	575.99	575.90	575.64
25	580.49	580.23	579.79	579.66	.....	578.84	577.66	576.84	576.43	575.99	575.85	575.62
26	580.53	580.35	579.82	579.71	*579.36	578.88	577.68	576.88	576.43	575.97	575.85	575.60
27	580.51	*580.23	579.79	579.69	.....	578.86	*577.66	576.82	576.41	575.96	575.84	575.59
28	580.43	580.23	579.69	579.56	.....	578.78	577.60	576.81	576.39	575.94	575.84	575.59
29	580.36	580.09	579.62	579.53	.....	578.73	577.61	576.87	576.45	576.03	575.96	575.65
30	580.46	580.41	579.91	579.78	.....	578.96	577.75	576.92	576.50	576.04	575.90	575.59
31	580.48	580.50	580.01	579.90	*579.47	579.06	577.82	576.97	576.50	*576.02	*575.88	575.59
Mean	580.40	580.21	579.68	579.60	579.19	578.80	577.63	576.85	576.43	575.99	575.88	575.62

*Less than 30 hourly readings.

Williams Exhibit 23.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Daily Mean Water Surface Elevations—Adjusted Levels of 1903

Sheet 2
(37 Sheets)
2-Table 2

June 1910	Harbor Beach	Fort Gratiot (Shore)	Sectina Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
A	B	C	D	E	F	G	H	I	K	L	M	N
1	580.61	580.43	579.90	579.77	.....	578.95	577.74	576.92	576.47	*575.90	575.88	575.59
2	580.59	580.76	579.94	579.80	.....	579.06	*577.73	576.90	*576.45	575.96	575.85	575.59
3	580.58	580.70	579.98	579.82	.....	*579.18	577.77	576.94	.....	576.02	575.90	575.65
4	580.43	580.31	579.79	579.64	*579.30	*579.02	577.70	576.90	*576.51	576.02	575.94	575.66
5	580.48	580.25	579.78	579.62	.....	578.86	577.69	576.91	576.50	576.03	575.99	575.71
6	580.54	580.37	579.86	579.71	.....	579.03	*577.74	576.96	576.53	576.06	575.97	575.71
7	580.62	580.45	*579.90	579.76	*579.41	578.98	577.76	576.97	576.53	576.06	575.96	575.69
8	580.57	580.36	579.84	579.71	.....	578.92	*577.71	576.92	576.52	576.05	575.95	575.72
9	580.49	580.45	579.82	579.67	.....	578.89	*577.69	576.90	576.48	576.02	575.93	575.67
10	580.55	580.65	579.88	579.71	.....	578.91	*577.69	576.81	576.46	576.00	575.90	575.66
11	580.61	581.07	579.96	579.78	.....	578.97	*577.72	576.78	576.44	576.01	575.89	575.65
12	580.69	580.42	*579.88	579.71	.....	578.93	*577.73	576.84	576.50	576.07	575.98	575.70
13	580.55	580.35	*579.82	579.66	.....	578.89	577.71	576.81	576.49	576.05	*575.96	575.70
14	580.58	*580.33	579.81	579.67	.....	578.88	577.70	576.85	576.48	576.04	*575.95	575.69
15	580.57	*580.35	579.83	579.67	.....	578.92	*577.71	576.92	576.48	576.04	575.95	575.68
16	580.53	.....	579.81	579.68	.....	578.90	.....	576.91	576.47	576.03	575.94	575.67
17	580.48	580.32	579.78	579.64	*579.12	578.85	*577.64	576.88	576.46	576.01	575.93	575.66
18	580.55	580.41	579.80	579.72	579.32	578.94	577.70	576.91	576.47	576.02	579.92	575.66
19	580.51	580.32	579.81	579.68	*579.32	578.89	577.67	576.90	576.46	576.01	575.92	575.65
20	580.54	580.36	579.83	579.71	.....	578.91	577.70	576.90	576.47	576.03	575.92	575.65
21	580.54	580.34	579.83	579.70	*579.32	578.92	577.70	576.91	576.47	576.03	575.92	575.66
22	580.51	580.31	579.79	579.68	.....	578.86	577.67	576.89	576.47	576.01	575.92	575.66
23	570.55	580.30	579.85	579.73	.....	578.94	577.72	576.91	576.48	576.02	575.93	575.66
24	580.53	580.43	579.89	579.74	*579.36	578.94	577.73	576.90	576.46	576.03	575.91	575.66
25	580.48	580.31	579.83	579.69	579.27	578.90	577.70	576.89	576.47	576.03	575.94	575.67
26	580.48	580.29	579.79	579.67	*579.25	578.88	577.69	576.89	576.47	576.02	575.93	575.67
27	580.52	580.30	579.80	579.69	.....	578.89	577.71	576.91	576.48	576.02	575.93	575.66
28	580.54	580.40	579.87	579.75	*579.34	578.97	577.77	576.93	576.49	576.03	575.94	575.66
29	580.53	580.35	579.84	579.71	579.30	578.92	577.74	576.91	576.48	576.02	575.94	575.65
30	580.50	580.29	579.79	579.68	*579.22	578.88	577.71	576.89	576.47	576.02	575.94	575.66
Mean	580.54	580.42	579.84	579.71	579.28	578.92	577.71	576.90	576.48	576.03	575.93	575.66

*Less than 23 hourly readings.

Williams Ex. 23.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Daily Mean Water Surface Elevations
Adjusted Levels of 1903

Sheet 3
(37 Sheets)
3-Table 2

July 1910	Harbor Beach	Fort Gratiot (Shore)	Section Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
a	b	c	d	e	f	g	h	i	k	l	m	n
1	580.50	580.32	579.73	579.66	*579.27	578.91	577.74	576.90	576.48	576.01	575.93	575.65
2	580.45	580.27	579.70	579.64	*579.27	578.88	577.72	576.90	576.48	576.01	575.94	575.65
3	580.34	580.49	579.82	579.76		578.98	577.70	576.93	576.50	576.02	575.94	575.63
4	580.46	580.53	579.85	579.78		579.00	577.81	576.92	576.48	576.01	575.91	575.61
5	580.28	580.26	579.70	579.65	*579.20	*578.86	577.72	576.90	576.49	576.03	575.96	575.65
6	580.24	580.16	579.61	579.54	*579.16	578.80	577.65	576.88	576.48	576.02	575.97	*575.66
7	580.46	580.28	579.72	579.64		578.90	577.72	576.91	576.49	576.03	*575.96	*575.65
8	580.30	580.16	579.62	579.56	*579.19	*578.84	577.67	*576.88	576.49	*576.02	*575.93	575.65
9	580.36	580.16	579.64	579.55	579.18	*578.86	577.69		576.51		575.98	575.67
10	580.40	580.21	579.64	579.58	579.24	*578.82	577.67		576.52		575.98	575.68
11	580.45	580.29	579.73	579.66	579.29	*577.92	577.71	*576.96	576.50		575.96	575.64
12	580.37	580.12	579.61	579.54	579.15	578.80	577.66	576.91	576.49		*576.02	575.66
13	580.48	580.38	579.80	579.72	*579.30	578.96	577.76	576.96	576.51	*576.08		575.65
14	580.30	580.21	579.62	579.56		578.86	577.66	576.92	576.48	576.05		575.66
15	580.41	580.32	579.67	579.61	*579.26	578.87	577.66	*576.90	576.48	576.04	575.96	575.65
16	580.42	580.38	579.79	579.66	579.31	578.96	577.75		576.49	576.03	575.99	575.65
17	580.45	580.39	579.80	579.73	*579.33	579.01	577.78		576.48	576.04	575.93	575.61
18	580.47	580.70	579.86	579.78	*579.46	579.03	577.77	*576.95	576.49	576.03	575.93	575.62
19	580.49	580.30	*579.74	579.65	579.27	578.93	577.74	576.93	576.51	576.06	575.98	575.65
20	580.34	580.08		579.50	579.13	578.79	577.65	576.86	576.47	576.03	575.95	575.65
21	580.42	580.15		579.51	579.21	578.86	577.67	576.85	576.47	576.03	575.97	575.63
22	580.49	580.19		579.58	579.27	578.90	577.67	576.85	576.48	576.02	575.96	575.62
23	580.20	580.31	*579.64	579.30	579.24	578.86	577.69	*576.90	576.48	576.03	575.96	575.62
24	580.13	*580.00	*579.46	579.43	579.10	578.74	577.67		576.50	576.06	576.02	575.67
25	580.46		579.81	579.75	579.47	578.98	577.82		576.56	576.10	576.02	575.66
26	580.44		579.78	579.68		578.98	577.81		576.54	576.08	576.01	575.66
27	580.44	*580.72	579.76	579.66	*579.37	*578.94	577.78	*576.95	576.53	576.07	576.00	575.65
28	580.43	580.32	579.79	579.67	579.30	578.95	577.76	576.94	576.53	576.07	575.99	575.65
29	580.36	580.22	579.72	579.62	579.26	578.92	577.75	576.96	576.55	576.10	576.03	575.69
30	580.33	580.47	579.93	579.79	579.42	579.02	577.82	576.97	576.55	576.07	575.98	575.64
31	580.45	580.29	579.80	579.66	579.29	578.93	577.76	576.92	576.51	576.06	575.98	575.64
Mean	580.42	580.30	579.73	579.64	579.28	578.90	577.73	576.92	576.50	576.04	575.97	575.65

*Less than 28 hourly readings.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Daily Mean Water Surface Elevations
Adjusted Levels of 1903

August 1910	Harbor Beach	Port Gratiot	Section Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
a	b	c	d	e	f	g	h	i	k	l	m	n
1	580.37	†580.13	579.58	579.85		578.83	577.73	576.92	576.53	576.08	576.04	575.68
2	580.39	580.25	579.66	579.63	*579.19	578.90	577.74	576.91	576.50	576.05	575.98	575.62
3	580.26	580.10	579.53	579.50	579.17	578.79	577.65	576.86	576.47	576.02	575.96	575.62
4	580.11	*580.22	579.51	579.75	*579.39	578.99	577.82	576.97	576.56	576.07	575.99	*575.56
5	580.05		579.50	579.60		*579.01	577.83	577.01	576.59	576.03	576.01	*575.50
6	580.16	*580.49	579.94	579.78	579.41		577.81	576.94	576.52	576.08	575.98	575.55
7	580.20	580.28	579.70	579.66	579.36		577.71	576.87	576.46	575.99	575.93	575.56
8	580.30	580.15	579.60	579.55	579.20		577.65	576.84	576.44	575.96	575.92	575.54
9	580.25	580.01	579.49	579.48	579.14	*578.79	577.61	*576.80	576.46	576.00	575.99	*575.56
10	580.30	580.21	579.66	579.59	579.20	578.80	577.67		576.44	575.99	575.93	*575.53
11	580.34	580.22	579.66	579.58	579.20	578.79	577.66		576.42	575.95	575.89	575.51
12	580.23	580.07	579.52	*579.47	579.09	578.70	577.58	*576.78	576.38	575.93	575.89	575.51
13	580.31	580.06	579.49	*579.48	579.10	578.70	577.56	576.77	576.36	575.91	575.87	575.49
14	580.30	580.14	579.57	579.54	579.14	578.74	577.61	576.79	576.38	575.92	575.86	575.48
15	580.26	580.13	579.56	*579.49	579.13	578.73	577.58	*576.77	576.36	575.90	575.86	575.47
16	580.29	580.16	579.62	579.55	579.14	*578.73	577.60	*576.81	576.36	575.90	575.86	575.47
17	580.27	580.16	579.57	579.51	579.13	578.74	577.58		576.36	575.90	575.86	575.47
18	580.40	†580.24	579.78	*579.66	579.32	578.90	577.69	*576.86	576.40	575.93	575.87	
19	580.37	580.23	579.78	*579.67	579.25	578.88	577.70	576.85	576.42	575.95	575.89	
20	580.21	579.99	579.48	579.45	579.07	578.69	577.56	576.77	576.37	575.93	575.90	*575.49
21	580.19	579.87	579.36	579.36	578.98	578.58	577.50	576.74	576.34	575.90	575.88	575.49
22	*580.14	*579.84	579.34	*579.36	*579.01	578.57	577.48	*576.72	576.32	575.88	575.84	575.47
23	*580.19	579.96	579.44	*579.40	579.14	578.64	577.55	576.72	576.29	575.86	575.80	575.43
24	*580.28	579.85	579.36	579.34	579.02	579.60	577.50	576.73	576.32	575.83	*575.80	575.45
25	*580.28	579.89	579.42	579.40	579.17	578.68	577.58	576.87	576.45	575.98	*576.15	575.49
26	*580.45	580.40	579.98	579.78	579.56	578.98	577.75	576.88	576.42	575.91	*575.85	575.42
27	*580.40	580.14	579.61	579.56	579.18	578.79	577.63	576.79	576.36	575.89	575.84	575.44
28	*580.28	580.15	579.65	579.59	579.18	578.79	577.62	*576.79	576.35	575.86	575.82	575.42
29	*580.32	580.13	579.70	579.68	579.20	578.79	577.61	*576.80	576.34	575.86	575.81	575.43
30	*580.16	579.86	579.60	579.35	579.03	578.60	577.48		576.30	575.86	575.82	575.45
31	*580.34	580.24	579.79	579.60	579.21	578.89	577.67		576.36	575.87	575.90	575.40
Mean.....	580.33	‡580.15 ‡580.08	579.60	579.55	579.18	578.77	577.64	576.83	576.41	575.94	575.90	575.50

*Less than 23 hourly readings.
†Gage at Shore.
‡Gage on Piles.
To Reduce from Gage on Piles to Gage at Shore add +0.07 ft.

Williams Ex. 23

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Daily Mean Water Surface Elevations

Adjusted Levels of 1903

Sheet 5
(27 Sheets)
5-Table 2

Sept., 1910	Harbor Beach	Fort Gratiot (Pilot)	Sectica Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Harsen Island	Salt Block	St. Clair Flats Canal
a	b	c	d	e	f	g	h	i	k	l	m	n
1	*580.37	580.34	579.82	579.70	*579.29	578.90	577.69	*576.82	576.36	575.90	575.81	575.40
2	580.34	580.30	579.85	579.48		578.71	577.55		576.32	575.89	575.82	575.45
3	580.19	580.08	*579.56	579.51	*579.34	*578.79	577.57		576.32	575.89	575.82	575.44
4	580.20	580.02	579.63	579.54	579.16		577.59		576.23	575.91	575.83	575.47
5	580.18	579.93	579.44	579.40	579.11		577.56			575.93		575.32
6	*580.17	579.91	579.44	579.40	579.16	*578.80	577.57	*576.83	*576.40	575.96	*575.93	575.80
7	*580.33	580.14	*579.84	579.80	579.19	578.81	577.94	576.81	576.37	575.92	575.94	575.46
8	580.34	580.06	*579.80	579.54	*579.10	578.72	577.59	*576.70	576.38	575.90	575.84	575.46
9	580.29	580.29	579.90	*579.35	579.09	577.76	*576.57	576.41	576.40	575.79	575.79	575.43
10	580.34	580.09		579.56	*579.13	578.76	577.60	576.78	576.35	575.90		575.45
11	580.27	580.01		579.47	579.12	578.70	577.53	576.75	*576.31	575.87		575.44
12	580.30	580.11	*579.41	579.59	579.35	578.80	577.61	*576.77	*576.37	575.87	*575.81	575.49
13	580.24	580.26	*579.93	579.74	579.46	578.90	577.68		576.34	575.87	575.77	575.38
14	580.21	580.10	579.80	579.55	*579.40	578.76	577.56		576.30	575.86	575.76	575.39
15	580.27	580.10	*579.62	579.54	*579.16	578.75	577.57	*576.78	576.30	575.84	575.76	575.38
16	580.28	579.99	*579.40	579.44	579.05	578.66	577.50	578.70	576.28	575.82		575.37
17	580.21	579.99		579.44	579.05	578.66	577.47	579.71	576.28	575.82		575.37
18	580.41	580.30	*579.84	579.66	579.34	578.85	577.62	576.77	576.33	575.83		575.36
19	580.13	579.66	*579.51	579.40	*578.92	578.61	577.45	576.64	576.24	575.78	*575.75	575.38
20	580.21	580.05	579.83	579.49	579.06	578.60	577.51	576.69	576.28	575.80	575.74	575.36
21	580.26	580.13	579.69	579.66	579.13	578.77	577.57	576.70	576.27	575.79	575.72	575.34
22	580.08	579.81	579.37	*579.33	578.88	578.53	577.39	576.61	576.19	575.74	575.70	575.33
23	580.08	579.91	579.36	*579.39	578.94	578.56	577.42	576.60	576.18	575.73	575.68	575.30
24	579.77	579.51	579.12	579.05	578.68	578.31	577.26	576.52	576.14	575.75	575.70	575.36
25	579.96	579.78	579.27	579.24	*578.96	578.43	577.33	576.53		575.70	575.67	575.38
26	580.10	579.90	*579.47	579.34	578.94	578.57	577.41	576.59	*576.18	575.72	575.68	575.36
27	579.96	579.73	*579.56	579.23	578.84	578.47	577.36	576.59	576.19	575.75	575.70	575.39
28	580.24	*580.02	579.84	579.46	579.09	578.68	577.50	576.64	576.20	575.73	575.68	575.33
29	580.08	*579.86	579.31	579.29	578.92	578.53	577.37	576.56	576.16	575.70	575.67	575.37
30	580.06	579.73	579.23	579.21	578.83	578.46	577.33	576.56	576.16	575.71	575.69	575.29
Mean	580.20	580.00	579.82	579.46	579.09	578.68	577.53	576.69	576.26	575.82	575.76	575.36

*Less than 24 hourly readings.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Daily Mean Water Surface Elevations
Adjusted Levels of 1903

Sheet 6
(37 Sheets)
6-Table 2

Oct. 1910	Harbor Beach	Fort Gratiot (Piles)	Section Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
a	b	c	d	e	f	g	h	i	k	l	m	n
1	580.40	*580.65	579.67	579.69	579.20	578.89	577.61	576.78	576.31	575.79	*576.71	*575.36
2	580.25	*579.88	*579.56	579.44	579.08	578.66	577.49	*576.65	576.20	575.72		*575.25
3	579.86	579.67	*578.97	579.06	578.66	578.22	577.21	*576.43	576.06	575.65	*575.56	*575.27
4	580.01	579.72	579.17	579.21	578.84	578.46	577.37	576.60	576.20	575.70	575.73	575.33
5	580.19	579.67	579.27	579.32	*578.89	578.54	577.37	576.56	576.15		575.68	575.29
6	580.39	580.34	579.81	579.78	*579.40	578.95	577.67	576.78	576.26	*575.71	575.65	575.29
7	580.25	579.98	579.48	579.46	579.05	578.67	577.43	*576.64	576.23			575.36
8	580.13	579.91	579.31	579.35	578.94	578.60	577.44		576.22	*575.62		575.38
9	580.40	*580.35	579.84	579.74	579.35	578.94	577.66		576.31	575.83	*575.68	575.34
10	580.13	579.89	579.47	579.38	578.98	*578.62	577.44	*576.62	*576.24	575.82	575.72	575.38
11	580.22	580.00	579.43	579.44	579.05	578.69	577.49	576.68		575.83	575.73	575.38
12	580.16	579.96	579.70	579.47	*579.11	578.70	577.46	576.61		575.74	*575.73	575.39
13	579.85	579.83	579.50	579.34		*578.34	577.20	576.45		575.68		575.31
14	580.04	579.87	579.38	579.32			577.37	576.56		575.72		575.23
15	580.02	579.79	579.40	579.23	*578.74	*578.36	577.32	576.53	*576.06	575.70		575.20
16	580.18	579.96	579.60	579.41	579.01	578.64	577.42		576.13	575.72	*575.61	575.27
17	579.92	579.75	579.20	579.19	578.83	578.47	577.28		576.09	575.67	575.58	575.26
18	579.90	579.72	579.15	579.19	578.80	578.44	577.26	*576.48	576.06	575.66	575.57	575.24
19	579.94	579.66	*579.14	579.13	578.77	578.40	577.24	576.45	576.06	575.64	575.57	575.24
20	580.10	579.86		579.46	579.04	578.64	577.41	576.54	576.09	575.65	575.54	575.26
21	579.73	579.46		579.00	578.63	578.27	577.19	576.43	576.03	575.67	575.57	575.28
22	579.97	579.66		*578.53	578.85	578.52	577.41	576.65	576.26	575.84	575.78	575.30
23	580.20	579.97			579.08	578.64	577.41	*576.89	576.13	575.67		575.18
24	579.97	579.65	*578.89	*579.13	578.75	*578.41	577.26	*576.47	*576.08	575.68	*575.61	575.23
25	580.04	579.58	579.40	579.22	578.94	578.57	577.36		576.06	575.62	575.53	575.15
26	580.03	579.81	579.36	579.23	578.87		577.29		576.08	575.61	575.53	*575.18
27	580.04	579.93	579.61	579.39	579.06	*578.53	577.44	*576.57	576.17	575.73	*575.64	575.19
28	580.18	580.10	579.65	579.50	579.09	578.73	577.48	576.60	576.16	575.70		575.14
29	580.09	*580.03	*579.69	579.40	579.01	578.65	577.40	576.52	576.07	*575.62		575.11
30	579.92	*579.34		578.96		578.33	577.27	576.52	576.14	*575.71		575.23
31	579.93	*579.70	*579.22	579.12	*578.76	578.41	577.21	576.36	575.97	575.53	*575.49	575.07
Mean.....	580.06	579.80	579.43	579.30	578.96	578.59	577.38	576.56	576.14	575.70	575.63	575.24

*Less than 23 hourly readings.

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Daily Mean Water Surface Elevations

Adjusted Levels of 1903.

Nov. 1910	Harbor Beach	Port Gratiot (Piles)	Section Gorge	G. T. R.	M. B. R.	Dry Dock Section	St. Clair	Marine City	Roberts Landing	Herson Island	Salt Block	St. Clair Flats Canal
A	B	C	D	E	F	G	H	I	K	L	M	N
1	579.63	579.14	*579.15	578.70		578.05	577.01	576.26	575.96	575.64	575.53	575.12
2	580.01	579.76	*579.23	579.27		578.48	577.95	576.40	575.98	575.55	575.48	575.02
3	*579.98	579.84	579.35	579.34	*575.85	578.50	577.24	576.36	575.93	575.48	575.43	575.02
4	579.98	579.72	579.30	579.25		578.44	577.21	576.35	575.92	575.49	575.44	575.06
5	*579.90	*579.72	579.10	579.16	*575.75	578.40	577.20	576.39	575.97	*575.41	575.50	575.08
6	*580.03	*579.74	579.22	579.23		578.55	577.33		576.04		575.53	575.05
7	*579.98		579.19	579.26		578.49	577.25		*575.98		575.49	575.03
8	579.90	579.78	579.30	579.24	*575.68	578.45	577.21	*576.36	*575.92		*575.44	575.00
9	579.79	*579.50	*579.00	579.09		578.20	577.14	576.33	575.91		575.42	575.03
10	579.91		*579.35	579.23		578.54	577.30	576.44	576.00		575.44	575.02
11	580.19	*580.11	579.41	579.52	*575.08	578.71	577.45	576.57	576.13	*575.72	575.51	575.05
12	580.13	580.14	*579.53	579.80		578.76	577.45	*576.55	576.07	575.62	575.45	574.98
13	580.08	580.05		579.47		578.54	577.36		576.02	575.59	575.44	575.00
14	579.87	579.74	*579.22	579.19	*575.70	578.40	577.17	*576.31	*575.92	575.50	575.37	574.99
15	579.90	579.84	579.35	579.26		578.47	*577.19	*576.26	575.95	*575.53	575.38	574.98
16	579.98	579.84	579.32	579.28		578.48			575.95		575.39	574.97
17	579.81	579.63	*579.18	579.08					575.89		575.36	574.97
18	579.76	579.63		579.07	*575.69	*578.33	*577.14	*576.36	575.87		575.38	*574.97
19	579.78	579.80		579.04		578.25	577.04	576.24	575.82		575.31	*574.95
20	579.86	579.28		578.79		578.04	576.86	576.12	*575.73		575.29	*574.92
21	579.86	579.34		578.76	*575.36	578.02	576.90	576.14	*575.78		575.31	574.91
22	579.68	579.30		578.90			576.93	576.12	575.72		575.23	574.84
23	579.44	579.06		578.61			576.78	576.05	575.60	*575.18	575.25	574.87
24	579.70	579.41		578.89			576.98	576.15	575.73	575.25	575.24	574.83
25	579.81	579.62	*579.23	579.07	*575.63	*578.25	577.05	576.25	575.77	575.28	575.23	574.83
26	579.82	579.60	*579.25	579.05		578.25	577.05	576.23	575.78	575.29	575.28	574.85
27	579.47	579.30	*579.24	578.70		577.96	576.91		575.65	*575.21	575.21	574.87
28	579.58	579.36	*579.26	578.86		578.09	576.91		575.73	*575.27	575.22	574.87
29	579.80	579.72	*579.34	579.20	*575.76	578.27	577.16	*576.36	575.92	575.41	575.23	*574.88
30	579.92	579.78		579.27		578.40	577.15	576.32	575.86	575.24	575.29	*574.86
Mean	579.80	579.62	579.27	579.12	575.72	578.27	577.13	576.31	575.90	575.48	575.37	574.96

*Lake Gauge 24 hourly readings.

Williams Exhibit 23.

U. S. LAKE SURVEY.

HYDRAULICS OF ST. CLAIR RIVER.

Daily Mean Water Surface Elevations.—Adjusted Levels of 1903.

Date 1906	Harbor Beach	Huronia Beach	Section Gage	G. T. R.	M. B. R.	Dry Dock Dunford	Roberts Landing	St. Clair Flats Canal
A	B	C	D	E	F	G	H	I
Nov. 1	580.71			579.87	579.47	579.06	576.53	575.48
2	580.65			579.80	579.37	578.97	576.51	575.48
3	580.70			579.85	*579.32	579.00	576.53	575.48
4	580.98			580.46		579.49	576.63	575.34
5	580.85			580.09	*579.55	579.22	576.59	575.45
6	580.71			579.91		579.06	576.54	575.43
7	580.70			579.84		578.99	576.46	575.37
8	580.58			579.69		578.86	576.39	*575.36
9	580.59			579.76	*579.35	578.90	576.32	s575.37
10	580.51			579.71	579.29	578.84	576.29	s575.32
11	580.80	*580.46		579.70	579.29	578.85	576.32	*575.31
12	*580.56	580.30		579.73	*579.35	578.90	576.41	575.27
13	580.49	580.52	*579.40	579.65	*579.22	578.81	576.30	575.23
14	580.38	580.30	*579.34	579.55	*579.13	578.72	576.28	575.23
15	580.25	579.97	579.13	579.30	578.96	578.54	576.36	575.25
16	580.52	580.48	579.48	579.67	579.27	578.84	576.36	*575.14
17	580.46	580.26	579.31	579.50	*579.12	578.68	576.18	s575.10
18	580.47	580.42	579.28	579.63	*579.32	578.77	576.19	s575.08
19	580.38	580.32	579.28	579.54	*579.36	578.68	576.14	s575.07
20	580.34	580.28	579.20	579.50	579.09	578.65	576.13	s575.11
21	580.24	580.19	579.21	579.41	*575.93	578.56	576.09	s575.10
22	580.13	580.04	579.09	579.28		578.45	576.05	s575.09
23	580.16	580.05	579.10	579.30	*578.91	578.45	576.04	s575.08
24	580.08	579.99	579.05	579.26		578.42	576.05	s575.07
25	579.99	*579.83	578.92	579.11		578.30	576.02	*575.06
26	580.14		579.01	579.18	*579.12	578.43	576.31	575.21
27	580.06		579.89	579.80	579.36	578.92	*576.37	575.12
28	580.46	580.04	579.32	579.50	*579.12	578.66	*576.24	575.12
29	580.37	580.20	579.32	579.52		578.66	576.16	*575.06
30	580.11			579.19		578.39	*576.17	s575.07
Mean	580.46	580.23	579.25	579.61	579.23	578.77	576.30	575.23
Dec. 1	580.01		*579.67	579.77		578.88		*575.13
2	580.88		579.79	580.01		579.13	*576.39	*575.10
3	580.34	*579.95	579.17	579.34	*578.85	*576.54	576.28	*575.16
4	580.34	580.43	579.33	579.52		578.71	576.23	575.06
5	580.37	580.41	579.31	579.52		578.66	576.14	575.01
6	579.99	579.91	578.99	579.09		578.32	576.05	s575.01
7	580.16	580.09	579.17	579.35	*579.13	578.57	*576.27	*575.08
8	580.35	*580.22	*579.29	579.44	579.04	578.65	576.27	575.04
9	580.32	580.35	579.28	579.47	579.04	578.63	576.13	574.97
10	580.10		579.01	579.18	578.78	578.30	576.05	*574.97
11	580.14	*580.13	579.12	579.26	578.85	578.46	576.09	*574.99
12	580.34	580.13	579.23	579.41	579.01	578.61	576.22	*575.00
13	580.32	580.12	*579.23	579.37	578.96	578.56	576.15	*576.00
14	580.17	579.98	*579.10	579.21	578.82	578.43	576.09	*575.00
15	580.33	580.18	*579.24	579.43	578.97	*578.54	576.07	*574.93
16	580.27	580.20	579.24	579.44	579.01	*578.56	576.06	*574.92
17	580.05	580.05	*579.06	579.26	578.83	578.43	576.00	*574.92
18	580.03			579.24	578.84	*578.54	576.10	s574.97
19	580.21		*579.14	579.27	*578.77	*578.56	576.22	*575.06
20	580.30		*579.39	579.37		578.86	*576.21	*574.90
Mean	580.27	580.15	579.25	579.40	578.92	578 59	576.16	575.02

*Less than 23 hourly readings.
sTri-daily Staff Gage readings.

Williams Ex. 23

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Daily Mean Water Surface Elevations.—Adjusted Levels of 1903.

Sheet 1 (37 Sheets)
Table I

Date 1909	Harbor Beach	Huronia Beach	Fort Gratiot (Crib)	Section Gorge	G. T. R.	M. B. R.	Dry Dock Detroit	Dry Dock Section	Roberts Landing	St. Clair Flats
A	B	C	D	E	F	G	H	I	K	L
Oct. 1	580.82				580.04		*579.23			578.20
2	580.86				579.92		579.09			578.34
3	580.86				579.94		579.00			578.34
4	580.82			*579.78	579.79	*579.33	578.97			*578.33
5	580.83			579.75	579.77	579.32	578.94			*578.32
6	580.83			579.72	579.74	579.30	578.93		*578.50	578.32
7	580.81			579.68	579.71	579.26	578.90		578.47	578.32
8	580.63		*580.37	579.64	579.68	579.20	578.85		578.43	578.40
9	580.41		*580.23	*579.62	579.64	579.15	578.82		578.43	578.40
10	580.31		580.09		579.60	579.04	578.72		578.40	578.40
11	580.27		579.96		579.43	*579.02	578.68		578.56	578.34
12	580.11		579.94	*579.01	579.16	578.84	578.54		578.73	578.30
13	580.45		580.03	579.48	579.40	579.09	578.73		578.53	578.32
14	580.56		580.31	579.68	579.67	579.25	578.98		578.43	578.34
15	580.54		580.26	579.60	579.69	579.26	578.96		578.36	578.33
16	580.59		580.39	579.77	579.77	579.33	578.94		578.41	578.33
17	580.52		580.03	579.72	579.71	579.28	578.87		578.30	578.19
18	580.43		580.01	*579.69	579.69	579.26	578.85		578.29	578.19
19	580.29				579.64	579.20	578.82		578.27	578.31
20	580.22				579.46	579.06	578.61		578.21	578.34
21	580.02			*579.20	579.20	*578.80	578.46		578.27	578.31
22	580.04			579.78	579.78	579.31	578.94		578.36	578.33
23	580.02			579.94	579.96	579.47	579.07		578.32	578.17
24	580.32				579.60	579.16	578.77		578.27	578.36
25	580.20			*579.21	579.36	578.86	578.51		578.20	578.33
26	580.23			579.37	579.36	578.94	578.57		578.28	578.29
27	580.50			*579.03	579.64	579.20	578.81		578.30	578.36
28	580.44				579.63	579.20	578.82	*578.70	578.28	578.38
29	580.24				579.43	*579.07	578.63	578.57	578.17	578.16
30	579.97				579.10		578.32	578.27	578.09	578.13
31	580.16				579.34	*578.86	578.48	*578.46	578.10	578.13
Mean	580.40		580.23	579.90	579.60	579.13	578.80	578.48	578.34	578.26
Nov. 1	580.02				579.06	*578.74	*578.32		578.06	*578.06
2	580.10				579.16	*578.91	578.46		578.19	*578.13
3	580.31				579.36	*579.01	578.69	*578.61	578.18	578.13
4	580.35	*580.36			579.44		578.74	578.71	578.19	578.09
5	580.17	*580.15			579.22	*578.90	578.68	*578.24	578.10	578.09
6	580.07	*580.00			579.28	578.87	578.47	578.40	578.06	578.06
7	579.86	579.89			578.96	578.60	578.23	578.17	578.08	578.06
8	580.39	*580.34			579.57	579.15	578.72	578.69	578.15	578.06
9	580.02				579.14	578.78	578.23		578.03	578.06
10	579.94				579.05	578.60	*578.23		578.01	578.06
11	579.96	*579.89			579.00	*579.67	*578.27	*578.26	578.03	*578.06
12	580.26	*580.06			579.43	579.04	578.61	*578.56	578.09	578.04
13	579.99	*579.89			579.09	578.72	*578.46		578.00	578.06
14	579.91				579.09	578.68	*578.22		578.00	578.06
15	580.33	*580.46			579.51	579.06	578.67	*578.72	578.13	578.06
16	580.06	579.79			579.09	578.74	578.34	*578.46	578.14	578.10
17	580.05	579.86			579.35	578.96	*578.01	*578.75	578.22	578.06
18	580.38	580.16			579.35	579.06		578.01	578.15	578.06
19	580.06	579.86			579.12	578.76		578.36	578.13	578.06
20	580.03	579.91			579.06	578.69		578.27	578.08	578.06
21	580.31	580.51			579.53	579.13		578.66	578.16	578.07
22	580.40	580.06			579.58	*579.13		578.69	578.23	578.06
23	580.23	580.50			579.44	*579.06		578.67	578.24	578.05
24	580.08	580.16			579.28			578.43	578.14	578.24
25	580.19	580.20			579.29			578.49	578.19	578.23
26	580.06	579.95			579.19	*579.77		578.40	578.14	578.21
27	579.90	579.44			578.98	578.59		578.19	578.08	578.15
28	580.26				579.49	579.04		578.61	578.13	578.15
29	580.15	*580.07			579.38	578.94		578.58	578.10	578.13
30	580.05	579.96			579.15	578.75		578.36	578.06	578.10
Mean	580.12	580.16			579.27	578.87	578.42	578.51	578.11	578.10
Dec. 1	580.02	580.02		*579.28	579.20	578.79		578.34	578.01	578.11
2	579.90	*579.86		*579.11	579.08	578.66		578.25	578.06	578.10
3	579.96	*579.97		*579.19	579.13	*578.68		*578.36	578.06	578.08
4	580.01	579.96		579.19	579.13				578.03	578.08
5	579.76	579.86		579.08	578.93				578.07	578.10
6	579.99	579.93		579.14	578.99	*578.57		*578.47	578.17	578.08
7	580.28	580.27		579.69	579.44	*579.06		578.89	578.32	578.12
8	580.33	579.96		*579.24	579.23			*578.80	578.40	578.16
9	580.41	580.26		*579.56	579.43	*579.08			578.57	578.17
10	580.40	580.32		*579.56	579.50	*579.16			578.57	578.11
11	580.12	*580.17		*579.44	579.26				578.13	578.12
12	579.76				578.94				*578.00	578.12
Mean	580.06	580.03		579.20	579.19	578.90		578.40	578.14	578.12

*Less than 23 hourly readings.

Williams Ex. 23

Sheet 10
(37 Sheets)
Table 6
W. S. Richmond, Jun. Engr.
April, 1911

U. S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

Time Interval required for Change of Lake Stage at Fort Gratiot to be Felt at Various Gages and Sections

GAGE OR SECTION	From Fort Gratiot Lighthouse Gage				Section from Channel Entrance Miles
	Miles	Time	Time to Nearest 10 Minutes	Minutes per Mile	
		h min.			
Section Gorge	0.45	1			
G. T. R.	0.80	2			
M. B. R.	2.45				
Dry Dock (Dunford)	4.65				
Dry Dock (Section)	5.10	16	20	3.14	
St. Clair	13.8	44	40	3.19	
Marine City	21.6	59	1:00	2.73	
Roberts Landing	25.6	1:09	1:10	2.69	
Section Sny	27.4	1:14	1:10		0.3
Section Bridge	30.8	1:32	1:30		0.8
Henson Island	32.4	1:37	1:40	2.99	
Salt Block (gage)	33.7	1:41	1:40	3.00	
Section M. C.	33.9	1:42	1:40		1.5
Section Salt Block	34.6	1:44	1:40		
Section Bassett	34.7	1:44	1:40		0.3
Section S. E. Bend	34.9	1:45	1:40		
St. Clair Flats	39.4	2 approx.	2 approx.	3.06?	

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Discharge of St. Clair River
Section Gorge

W. S. Richmond, Jun. Engr.
April, 1911.

Number	Date	Water Surface Elevations				Fall		Change at lake		Wind		Ratings				Volume of Discharge (cu. ft. per sec.)					Weighted mean Index Velocity
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to D.D.	Rise	Fall	Dir.	Vel. miles	1B	10B	14B	15B	1B	10B	14B	15B	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
61	1910 May 9	(Sluice) 580.33	579.66	578.89	575.69	.84	.76	.09	.00	N.W.	15		K	L				187,160	191,500		189,230	5.23
62	9	.36	.70	.91	575.67	.66	.79	.04	.02	N.W.	13		K	L				186,860	190,060		188,310	5.23
63	17	579.98	.13	.42	.56	.80	.76	.15	.05	S.E.	30	K				165,560					165,560	5.53
64	17	.65	579.98	.33	.66	.67	.68	.02	.27	S.-S.E.	60-20		K					165,430			Rejected	4.90
65	18	580.23	579.63	.64	.58	.60	.70	.26	.02	W	40			L	M							
66	18	.24	.66	.53	.57	.88	.84	.17	.01	W	45-55			L	M			188,470	187,540	188,020	5.22
67	18	.41	.72	.94	.57	.66	.79	.04	.03	W	40			L	M			185,570	187,710	186,640	5.16
68	18	.24	.44	.61	.33	.78		.00	.41	S.E.	6	K	K			120,050	178,040	190,040	191,800	180,920	5.30
69	18	.10	.32	.67	.33	.67	.86	.21	.02	S.E.	8	K	M			120,100	163,280			179,040	5.98
70	18	.16	.34	.71	.34	.62	.83	.11	.07	S.	10	K	M			165,730	179,560			186,340	6.19
71	18	.09	.46	.86	.36	.62	.77	.08	.07	S.	15	K		L		178,190		176,190		182,660	6.08
72	18	.62	.63	.84	.55	.60	.78	.00	.14	S.	18	K		L	M	175,850		173,560		177,190	5.88
73	20	579.93	.34	.61	.36	.86	.79	.11	.00	S.E.	5			L	M			173,220	181,080	174,720	5.83
74	20	580.07	.47	.67	.53	.80	.80	.06	.01	S.E.	6			L	M			177,940	181,760	179,640	5.98
75	20	.04	.44	.63	.36	.60	.79	.00	.04	S.E.	10		M		M		186,570		181,000	178,550	5.93
76	20	.00	.41	.64	.33	.60	.77	.06	.04	S.E.	8		M		M		178,270		178,240	180,940	6.02
77	20	.12	.53	.72	.54	.60	.81	.07	.00	S.W.	3		M	L			186,960	187,200		178,300	5.93
78	21	.19	.54	.75	.55	.65	.79	.02	.03	N.W.	12	K								187,220	6.21
79	21	.15	.53	.75	.55	.65	.78	.01	.06	N.W.	10	K				188,150				188,150	6.21
80	June 13	.34	.74	.92	.70	.60	.82	.10	.00	S.W.	6		M		M	187,630				187,630	6.19
81	13	.41	.77	.96	.70	.64	.81	.07	.04	S.W.	8		M		M		185,780		189,960	188,370	6.24
82	13	.31	.66	.86	.70	.66	.78	.02	.04	S.W.	10		M				189,560		191,440	190,510	6.28
83	13	.32	.68	.90	.71	.64	.78	.01	.01	S.W.	6	K	M			188,930	187,830			188,380	6.32
84	13	.37	.77	.95	.71	.60	.82	.07	.01	S.W.	13	K		L		187,230	188,310			187,800	6.20
85	14	.33	.68	.90	.71	.64	.86	.00	.00	S.	2	K		L		186,740		188,710		187,730	6.16
86	14	.22	.65	.86	.69	.67	.87	.00	.01	N.E.	2				M			190,510	189,310	189,910	6.27
87	14	.32	.69	.89	.69	.63	.79	.01	.01	N.E.	4	K			M			188,120	186,790	187,455	6.20
88	14	.33	.70	.91	.69	.63	.79	.00	.00	N.E.	6	K			M	190,300			189,280	189,800	6.27
89	14	.33	.67	.89	.68	.66	.78	.00	.00	N.E.	4	K	M			189,450			189,130	189,290	6.26
90	14	.23	.57	.80	.68	.66	.78	.00	.00	N.E.	4	K	M			185,370	184,080			184,720	6.11
91	17	.29	.61	.71	.67	.68	.90	.03	.04	S.W.	4	K	M			187,080	186,070			186,580	6.16
92	17	.35	.66	.92	.68	.65	.76	.05	.01	S.E.	2	M	M			185,540	186,180			185,860	6.15
93	18	.48	.83	.99	.67	.65	.84	.14	.02	N.W.	8	M	M	M		185,490	187,080			186,280	6.16
94	18	.43	.79	579.00	.67	.64	.79	.15	.23	N.W.	8	M	M	M			191,040	191,780		191,410	6.30
95	18	.42	.76	578.96	.67	.63	.84	.13	.17	N.W.	6	M	M	M			186,220	187,820		187,020	6.15
96	18	.44	.76	.98	.68	.64	.75	.04	.23	N.W.	15		M	M	M			190,960	189,650	190,300	6.26
97	18	.39	.69	.97	.67	.62	.83	.09	.20	N.W.	16	M			M	189,360		185,890	185,410	185,650	6.13
																			188,660	189,000	6.26

*Observations supplied.

HYDRAULICS OF ST. CLAIR RIVER
Discharge of St. Clair River
Section Gorge

(Sheet 12 of 13 sheets)
W. S. Richmond, Asst. Engr.
April, 1911

Number	Date	Water Surface Elevations				Fall		Change at lake		Wind		Ratings				Volume of Discharge (cu. ft. per second)					Weighted Mean index velocity
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to D. D.	Rise	Fall	Dir.	Vel. Miles	1B	10B	14B	15B	1B	10B	14B	15B	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
	1910	(Shore)																			
98	June 29	580.28	579.66	578.89	575.66	.62	.77	.13	.11	N.	4	M			M	178,530			181,150	179,840	5.93
99	30	.34	.70	.91	.66	.64	.79	.12	.13	N.E.	5	M			M	183,120			186,000	184,560	6.09
100	30	.36	.73	.94	.66	.63	.79	.14	.12	N.E.	4	M	M			184,760	188,710			186,740	6.16
101	30	.40	.76	.94	.66	.62	.84	.24	.12	N.W.	2	M	M			188,740	192,490			190,620	6.28
102	30	.33	.72	.92	.66	.61	.80	.08	.13	N.E.	10		M	M			188,980	186,260		186,620	6.22
103	29	.38	.75	.94	.67	.69	.81	.12	.01	N.W.	4			M	M			193,720	193,480	193,600	6.38
104	29	.43	.80	579.01	.66	.63	.79	.05	.02	N.W.	2			M	M			193,310	191,750	192,530	6.34
105	29	.41	.74	578.96	.66	.67	.78	.00	.00	N.W.	4			M				186,710		186,710	6.16
106	30	.37	.63	.85	.66	.65	.77	.03	.03	N.W.	2	O	M			186,990	186,890			186,940	6.15
107	30	.28	.65	.87	.67	.63	.78	.01	.01	S.	2	O	M			185,130	185,270			185,200	6.13
108	30	.28	.68	.88	.68	.60	.80	.00	.00	S.W.	2										
109	30	.28	.66	.88	.66	.62	.78	.01	.01	N.E.	4		M		M		184,770		184,770	184,770	6.14
110	30	.28	.65	.86	.66	.63	.79	.01	.01	N.E.	3		M		M		181,700				
111	July 1	.33	.69	.90	.64	.64	.79	.01	.01	N.E.	2			M	M			182,980	182,340	182,660	6.08
112	1	.25	.63	.85	.64	.62	.78	.06	.02	S.W.	4	O		M				184,030	184,780	184,408	6.09
113	1	.30	.70	.89	.65	.60	.81	.00	.10	S.W.	4	O		M		185,660		185,000		184,330	6.10
114	1	.33	.68	.90	.65	.65	.78	.07	.00	N.W.	4	O			M	184,570		182,940		183,550	6.06
115	1	.30	.64	.88	.64	.66	.78	.01	.03	N.E.	2	O			M	188,480			189,090	188,780	6.24
116	2	.29	.63	.90	.64	.66	.73	.01	.01	S.W.	2		M		M	185,960			186,810	186,380	6.02
117	2	.28	.60	.88	.66	.68	.72	.00	.03	S.W.	2		M	M			184,130		185,850	185,090	6.12
118	2	.24	.56	.81	.66	.68	.75	.02	.02	S.W.	2		M	M			185,630	183,930		184,780	6.12
119	2	.27	.62	.86	.64	.65	.74	.05	.01	S.W.	4	O		M		184,960	184,180	181,840		183,010	6.06
120	5	.33	.69	.89	.65	.64	.80	.23	.15	N.E.	9	O		M		190,060		187,480		188,780	6.26
121	5	.36	.68	.86	.65	.68	.82	.15	.06	N.E.	12			M	M			189,980	190,580	190,280	6.29
122	5	.25	.60	.80	.65	.65	.80	.08	.01	N.E.	12	O				189,230		189,010		189,120	6.25
123	Aug. 5	.22	.62	.84	.54	.60	.78	.05	.00	N.W.	2	O	M			194,790	185,050			184,910	6.12
124	6	.21	.56	.78	.54	.65	.80	.01	.03	N.E.	2			O	O			185,410	187,100	186,260	6.18
125	8	.19	.58	.80	.54	.61	.78	.10	.05	N.E.	2-10		O	O			186,620	183,610		185,080	6.14
126	8	.14	.52	.74	.55	.62	.78	.01	.03	N.E.	4	O	O			184,120	183,350			183,740	5.92
127	9	579.94	.38	.63	.54	.56	.75	.05	.01	S.	15	O			O	181,660			181,460	181,570	6.04
128	9	.96	.32	.56	.54	.64	.76	.02	.04	S.	15		O	O			177,470	174,720		176,100	5.88
129	9	.95	.39	.63	.54	.56	.76	.00	.04	S.	10		O	O			174,540	172,070		173,300	5.79
130	9	.98	.43	.71	.60	.53	.74	.04	.00	S.	10-30			O	O			167,790	168,470	168,130	5.61
131	9	.99	.45	.75	.60	.51	.73	.11	.00	S.	35			O	O			170,630	172,120	171,370	5.99
132	10	580.14	.57	.89	.51	.57	.86	.05	.01	N.	20-40	O			O	176,260			174,630	175,440	5.84
133	10	.18	.56	.82	.51	.62	.74	.04	.00	N.	5		O		O		186,830		185,800	187,310	6.23
134	10	.22	.63	.81	.51	.59	.82	.04	.00	N.	6		O		O		186,020		183,040	184,530	6.12
													O	O			188,100	184,680		186,390	6.18

*Elevations supplied.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Discharge of St. Clair River
Section Gorge

W. S. Richmond, Jun. Engr.
April, 1911

Number	Date	Water Surface Elevations				Fall		Change at Inlet		Wind		Ratings				Volume of Discharge (cu. ft. per sec.)					Weighted Mean Index Velocity
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. Gr. to G.T.R.	G.T.R. to D. D.	Rise	Fall	Dir.	Vel. Miles	1 B	10 B	14 B	15 B	1 B	10 B	14 B	15 B	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
	1910	(Shore)																			
135	Aug. 10	580.24	579.50	578.82	575.52	65	.77	.01	.02	N.	6		O	O			186,970	183,310		185,390	6.15
136	10	.24	.61	.82	.53	63	.79	.02	.01	N.	5		O		O		186,990		185,530	186,260	6.19
137	10	.24	.61	.81	.54	63	.80	.02	.01	N.	4		O		O		186,270		185,150	185,710	6.16
138	11	.24	.58	.82	.51	66	.76	.01	.15	N.	6			O	O			184,010	183,960	183,980	6.10
139	11	.22	.59	.81	.50	63	.78	.11	.03	N-N.E.	10			O	O			185,180	184,560	184,870	6.13
140	11	.27	.64	.82	.50	63	.82	.13	.07	N.E.	10-20	O			O	187,030			186,610	186,820	6.19
141	11	.21	.58	.83	.51	63	.75	.02	.11	N-N.E.	18	O			O	183,720			182,330	183,020	6.07
142	11	.18	.54	.78	.53	64	.76	.03	.08	N.W.	10	O	O			184,990	184,030			184,510	6.13
143	12	.11	*.50	.72	.50	*.61	*.76	.00	.08	S.W.	4		Q	O			180,030	179,590		179,810	5.99
144	12	.04	*.43	.70	.50	*.61	*.72	.00	.05	S.W.	3		Q	O			176,700	175,810		176,260	5.87
145	12	.06	*.47	.71	.50	*.61	*.76	.04	.02	N.E.	8			O	O			178,320	176,480	177,400	5.74
146	12	.10	*.49	.74	.50	*.61	*.75	.09	.12	N.E.	6			O	O			180,260	181,750	181,000	6.02
147	12	.05	*.45	.69	.50	*.60	*.76	.06	.05	N.E.	5	O			O	181,350			179,340	180,340	6.01
148	12	.02	*.42	.67	.49	*.60	*.75	.11	.06	S.W.	6	O	Q			182,100	181,740			181,920	6.07
149	13	579.95	*.31	.56	.49	*.57	*.75	.02	.12	S.W.	3	O	Q			172,470	172,300			172,380	5.77
150	13	580.15	*.52	.76	.48	*.62	*.77	.23	.05	S.W.	5	O			O	184,610			183,280	183,940	6.12
151	13	.06	*.45	.71	.48	*.61	*.77	.05	.13	S.W.	5			O	O			179,520	179,300	179,420	5.98
152	13	.07	*.46	.71	.48	*.61	*.75	.15	.00	S.W.	6		Q	O			180,890	181,940		181,420	5.96
		(piles)																			
153	Sept. 12	579.92	.57	.61	.34	55	.78	.16	.15	N.E.	8	R		Q		180,840		179,700		180,130	6.01
154	19	.97	.42	.65	.35	55	.77	.10	.16	N.E.	8	R	S	Q		183,430	181,160			182,300	6.08
155	20	580.01	.44	.65	.35	57	.79	.22	.12	S.	6		S	Q	S			180,810	180,890	180,840	6.02
156	20	.17	.60	.76	.35	58	.83	.23	.07	S.	6		S		S		188,300		187,610	188,000	6.24
157	20	.06	.51	.73	.37	.54	.78	.10	.22	S-S.W.	8	R				182,310				182,310	6.06
										N.	12										
158	20	.04	.49	.71	.36	55	.78	.00	.03	N.	10	R	S			179,790	173,480			176,640	5.87
159	21	.14	.55	.75	.35	.59	.80	.15	.11	W.-S.W.	5	R			S	187,800			182,810	185,300	6.15
										W.	3										
160	21	.22	.64	.83	.35	.66	.81	.05	.09	N.E.	15	R	S			187,320	186,230			186,780	6.18
161	22	579.80	*.25	.45	.26	*.52	*.80	.15	.10	S.E.	3		S	Q			178,140	178,970		178,560	5.98
162	22	.91	*.37	.54	.28	*.54	*.83	.10	.02	S.	3			Q	S			183,370	181,230	182,300	6.11
163	23	.93	*.39	.60	.30	*.54	*.79	.11	.15	N.W.	3	R			S	182,460			180,670	181,580	6.17
164	23	.97	.44	.66	.30	.53	.79	.11	.14	S.E.	2	R	S			181,030	181,040			181,040	6.05
165	24	.41	.00	.30	.26	.41	.70	.13	.12	E.-S.E.	25			Q	S			166,520	166,010	166,320	5.50
166	24	.33	578.92	.20	.23	.41	.72	.14	.10	E.-S.E.	20			Q	S			165,010	164,180	164,600	5.56
167	24	.38	.94	.34	.26	.70	.44	.10	.05	E.-S.E.	20-10	R				168,990		167,500		168,240	5.60
168	24	.25	.87	.25	.27	.41	.62	.20	.15	S.E.	15	R		Q	S	162,710		161,010		161,860	5.49
169	25	580.01	579.43	.00	.28	.58	.83	.18	.28	N.E.	10		S		S		184,640		183,880	184,120	6.14
170	25	579.90	.34	.38	.27	.56	.78	.20	.28	N.E.	8		S		S		182,210		180,710	181,460	6.09
171	27	.69	.13	.36	.26	.60	.74	.18	.15	S.W.	12-18		S	S			171,280	169,250		170,250	5.79
172	27	.73	.10	.37	.26	.63	.73	.20	.20	S.W.	16		S	S			173,160	172,600		172,880	5.85

Number	Date	Water Surface Elev.				Fall		Change at Lake		Wind		Ratings				Volume of Discharge (cu. ft. per sec.)					Weighted mean index velocity
		Fort Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to D.D.	Rise	Fall	Dir.	Vel. miles	1B	10B	14B	15B	1B	10B	14B	15B	Adopted	
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	V	W
	1910	(Piles)																			
173	Sept. 27	579.66	579.14	578.44	575.22	.51	.70	.19	.07	W.	10			S	S			168,860	169,000	168,930	5.50
174	27	.72	.20	.47	.29	.52	.73	.07	.16	S.W.	15			S	S			174,320	174,890	174,600	5.86
175	27	.75	.24	.50	.29	.51	.74	.11	.15	W.-S.W.	15			S	S			177,000	177,470	177,240	5.96
176	28	*580.16	.57	.78	.25	*.59	.79			N.W.	8			S	S			189,350	188,860	189,100	6.23
177	28	* .17	.58	.79	.25	*.59	.79			N.	8	R			S	187,350			185,430	186,390	6.15
178	28	* .04	.47	.67	.25	*.57	.80			N.E.	8	R				186,920		185,750		186,340	6.20
179	28	* .06	.49	.70	.25	*.57	.79			N.-N.E	10		S	S	S		184,080	183,800		183,940	6.12
180	28	* .11	.53	.73	.26	*.58	.80			N.N.E	8		S	S	S		187,800		187,600	187,700	6.24
181	Oct. 24	579.31	*578.87	* .17	.27	*.44	*.70	.13	.06	S.W.	30			T	S			158,070	159,120	158,600	5.86
182	24	.62	*579.13	* .39	.26	*.50	*.74	.14	.11	S.-S.W.	20		S	T			169,150	168,220		168,680	5.99
183	24	.57	.05	* .31	.22	.52	*.74	.14	.04	S.W.	8	S	S			166,660	166,070			166,360	5.91
184	25	.57	.10	* .47	.17	.61	*.79	.09	.04	W.-S.W.	8	S		T		184,620		184,970		184,800	6.18
185	26	.54	.26	* .48	.16	.58	*.78	.06	.12	W.	4	S			S	181,190			180,970	181,080	6.05
186	26	.66	.12	* .37	.16	.54	*.78	.08	.19	W.-S.W.	7		S		S		173,970		172,330	172,650	5.79
187	26	.74	.16	* .39	.16	.58	*.77	.12	.07	W.-S.W.	6			T	U			177,910	177,660	177,780	5.96
188	26	.79	.22	* .46	.15	.56	*.77	.11	.11	S.-S.W.	10		S	T			179,100	179,740		179,420	6.02
189	26	580.45	.79	.98	.11	.66	.84	.30	.00	N.W.	20-30		U	T			204,210	202,980		202,600	6.71
190	31	579.81	.30	.45	.06	.51	.75	.13	.24	S.-S.W.	6	S			U	183,320			183,250	183,280	6.15
191	31	.82	.31	.48	.06	.51	.73	.12	.10	S.-S.W.	6			T	U			181,640	180,540	181,090	6.08
192	Nov. 1	.31	578.85	.20	.09	.46	.66	.06	.17	S.-S.E.	12		U	T			164,760	166,950		165,860	5.63
193	1	.17	.72	.10	.07	.45	.62	.04	.07	S.-S.W.	20	S	U			156,760	156,010			156,380	5.33
194	1	.25	.76	.06	.09	.49	.70	.23	.05	S.-S.W.	18-35	S		T	U	163,060		164,860		163,960	5.57
195	1	.24	.83	.15	.11	.41	.68	.07	.30	S.-S.W.	35		U	T	U			164,130	161,230	162,680	5.52
196	1	.08	.98	.01	.09	.40	.67	.08	.03	S.-S.W.	25				U		153,490		153,270	153,380	5.22
197	2	.66	579.12	.27	.02	.54	.85	.08	.00	W.N.W.	15	S	U	T	U	180,310			179,600	179,960	6.06
198	2	580.00	.45	.60	.01	.55	.85	.01	.08	W.N.W.	12		U		U		188,110	190,000		189,060	6.34
199	2	579.78	.21	.40	.01	.54	.81	.20	.00	W.N.W.	10		U	T	U		178,960		181,090	180,030	6.05
200	2	580.03	.46	.63	.01	.57	.93	.36	.00	N.N.W.	2			T	U			192,650	192,030	192,340	6.44
201	2	.16	.58	.69	.02	.58	.89	.09	.12	N.N.W.	3			T	U			194,320	193,100	193,710	6.48
202	9	*579.52	.02	.26	.07	*.50	.76			S.-S.E.	8	U		T	U			169,000		168,440	5.70
203	9	* .54	.04	.23	.05	*.50	.79			S.	25			T	U	167,880		176,150	173,490	173,820	5.88
204	9	* .51	.01	.26	.01	*.50	.73			S.	6		U	U	U		169,840		169,160	169,500	5.73
205	9	* .61	.09	.22	.01	*.52	.87			S.	4		U	U			178,500	180,800		179,650	6.09
206	11	.97	.39	.56	.04	.58	.83	.17	.00	W.	20				U		184,790		186,220	185,510	6.22
207	11	580.17	.57	.72	.04	.60	.85	.20	.12	W.	25-35			T	U			190,940	189,340	190,140	6.36
208	11	579.99	.45	.66	.07	.54	.77	.14	.07	W.	35-20	U				185,800		184,340		185,070	6.19
209	11	580.14	.53	.70	.07	.62	.82	.33	.03	W.	20	U				190,090				190,090	6.35

*Elevations supplied.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER.
Discharge of St. Clair River,
Section Dry Dock.

Sheet 18
(37 Sheets)
Table 11
W. S. Richmond, Jun. Engr.
April, 1911

Number	Date	Water Surface Elevations				Fall		Change at Lake		Wind		Ratings					Volume of Discharge (cubic ft. per second)					
		Port Gratiot	G.T.R.	Dry Dock Section	St. Clair Flats	Ft. G. to G.T.R.	G.T.R. to Dry Dock	Rise	Fall	Dir.	Vel. Miles	1B	10B	14B	15B	713	1B	10B	14B	15B	713	Adopted
A	B	C	D	E	F	G	H	Z	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
	1910	(Shore)																				
290	June 22	580.29	579.67	578.86	575.65	0.62	0.79	0.19	0.22	N.E.	2			M		K			122,870		191,150	182,670
291		.27	.66	.85	.65	.61	.78	.22	.24	N.E.	4		M	M				168,630	187,830			185,330
292		.30	.67	.86	.65	.63	.79	.14	.21	S.W.	2		M		M			188,200		188,460		185,280
293		.41	.76	.94	.65	.65	.83	.10	.07	N.E.	4	M			M		188,320			190,190		189,260
294		.43	.80	579.00	.65	.63	.80	.21	.25	N.E.	2-6	M		M			190,660		189,830			190,240
295		.39	.75	578.97	.66	.64	.78	.16	.07	N.E.	4-6		M	M				191,180	187,350			189,200
296		.46	.79	.96	.66	.67	.81	.10	.06	N.W.	12		M		M			190,940		196,140		190,080
297		.51	.80	579.00	.67	.71	.80	.09	.08	N.W.	13	M			M		192,560			195,050		193,580
298		.45	.74	578.94	.66	.71	.80	.22	.16	N.W.	20	M		M			192,360		192,500			192,480
299		.37	.65	.95	.67	.72	.90	.13	.16	N.E.	4			M	M				194,790	188,450		186,620
300		.39	.74	.95	.66	.65	.79	.14	.06	N.W.	10		M		M			194,150		192,020		193,080
301		.27	.26	.87	.65	.61	.78	.06	.22	N.W.	6	M	M				183,970	187,830				185,900
302		.33	.70	.90	.66	.63	.80	.12	.07	N.W.	2	M		M			188,570		190,360			189,460
303		.39	.66	.93	.67	.63	.78	.04	.09	S.W.	6			M		K			184,300		185,330	184,980
304		.40	.75	.97	.68	.65	.78	.16	.31	N.W.	4-8		M		M			192,480		192,120		192,300
305	July 6	.18	.55	.83	.64	.63	.72	.21	.33	S.S.W.	8	O	M				181,030	184,830				182,930
306	6	.10	.49	.78	*.63	.61	.71	.30	.24	S.W.	12		M		M			183,530		181,560		182,540
307	9	.19	.57	.84	.64	.62	.73	.13	.09	S.W.	3	O		M			180,900		182,030			181,460
308	9	.26	.64	.90	.65	.62	.74	.04	.05	S.E.	15			M	M				182,280	185,980		185,980
309	21	.21	.51		.60	.70		.46	.78	S.W.-N.E.	2-20			M	M							Rejected
310	21	.16	.51	578.84	.62	.65	0.67	.41	.63	S.S.W.-S.E.	25-30		M	M				179,450	177,500			178,520
311	22	.23	.63	.90	.62	.60	.73	.22	.12	S.-S.W.	10-12		M		M			186,830		186,960		186,900
312	23	.21	.59	.87	.60	.62	.72	.05	.07	S.	2-5			M	M				183,460	183,200		183,380
313	23	.29	.64	.92	.63	.64	.72	.12	.10	S.-S.W.	5-45	O			M		184,390			182,580		183,980
314	Aug. 2	.31	.68	.95	.62	.63	.73	.12	.06	N.E.-N.N.E.	6-8		Q		Q			188,910		186,420		187,660
315	2	.29	.62	.86	.62	.67	.76	.06	.21	N.-N.N.E.	5-8		Q					182,450	183,780			183,120
316	3	.15	.52	.83	.61	.63	.69	.08	.23	E.-S.W.	2-2	Q		Q			178,230		181,000			181,000
317	3	.10	.49	.77	.62	.61	.72	.29	.21	S.-S.S.W.	4-7	Q					174,000	180,380				180,380
318	4	.36	.64	.91	*.66	.62	.73	.07	.00	W.-W.S.W.	18		Q		Q			184,430		183,340		183,890
319	4	*.44	.79	579.06	*.72	*.65	.71	.07	.00	WSW.-WNW.	18-30		Q		Q				188,510	188,220		188,360
320	4	*.55	.86	.07	*.64	*.67	.81			NNW.-NW.	20-25		Q		Q			192,670	191,790			192,230
321	5	*.33	.69	578.92	.60	*.64	.77			W.S.W.-W.	18-20		Q					183,460	183,190			183,320
322	5	*.50	.84	579.04	.64	*.66	.80			S.W.	20-35		Q		Q				188,190	188,700		188,440
		(Piles)																				
323	Sept. 7	.21	.63	578.84	.48	.58	.79	0.11	0.07	S.E.	0-2		Q		Q			186,520	186,950			186,740
324	7	.14	.56	.82	.46	.56	.77	.09	.12	S.-S.E.	2		Q		Q			187,100		178,030		187,100
325	8	579.84	.32	.58	.46	.52	.74	.08	.24	S.S.E.-S.	4-18		Q		Q				173,170	168,910		173,170
326	8	580.00	.45	.66	.46	.55	.79	.27	.21	S.	15		Q		Q			183,740		178,410		183,740
327	8	.24	.61	.79	.47	.63	.83	.30	.01	S.	15		Q		Q			186,040	187,480			186,760
328	9	.56	580.00	579.16	.40	.56	.84	.08	.22	N.N.W.	28-30		Q		Q				202,950	193,440		202,950
329	9	.23	579.75	578.96	.44	.53	.77	.36	.20	N.W.-N.E.	30-10		Q		Q			189,230	191,740			191,740
330	10	.10	.52	.78	.44	.57	.78	.13	.09	S.	4	Q			Q		182,780		185,720			184,260
331	11	.03	.50	.70	.43	.53	.80	.04	.11	S.	4	Q			Q		181,310	179,870				181,310
332	11	.17	.58	.81	.45	.59	.77	.09	.11	W.S.W.-W.	8-45							187,000	220,440			203,720
333	Oct. 11	.10	.58	.81	.45	.52	.77	.07	.07	W.S.W.	20-30							186,580		180,810		Rejected

126

Williams Exhibit 23.

U. S. LAKE SURVEY.
HYDRAULICS OF ST. CLAIR RIVER
Summary of Discharge
Section Say.

Sheet 16
(37 Sheets)
Table 13
W. S. Richmond, Jun. Engr.
April, 1911

Number	Date 1910	Wind		Water Surface Elevations					Discharge of River	Channel Discharge						Mean Channel Discharge	Per cent of Flow
		Dir.	Vel.	Fort Gratiot	G.T.R.	Dry Dock	Roberts Landing	St. Clair Flats		Meter	Rating	Discharge	Meter	Rating	Discharge		
A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S
1	May 25	W.	10	(Shore) 580.31	579.66	578.86	576.42	575.61	186,800	10B	M	11,360	15B	L	11,340	11,350	6.1
2	" 25	N.W.	12	.32	.69	.87	.43	.61	187,200	10B	M	11,360	1B	K	11,320	11,340	6.0
3	" 25	N.W.	12	.40	.68	.86	.43	.59	190,800	1B	K	11,340	14B	K	11,380	11,360	6.0
4	" 25	N.W.	8	.40	.63	.82	.40	.68	189,700	15B	L	11,170	14B	K	10,840	11,005	5.8
5	" 25	N.W.	6	.35	.64	.83	.42	.66	187,500	15B	L	11,660	713	K	11,510	11,585	6.2
6	July 11	S.	6	.30	.67	.96	.51	.67	185,300	10B	M	10,580	15B	M	10,900	10,740	5.8
7	" 12	S.E.	15	.03	.42	.72	.52	.68	175,200	15B	M	10,390	10B	M	10,070	10,230	5.8
8	" 12	S.E.	15	.03	.47	.82	.54	.65	175,900	15B	M	10,660	14B	M	10,420	10,540	6.0
9	" 12	S.E.	15	579.97	.41	.73	.47	.64	173,900	14B	M	10,130	10B	M	10,140	10,140	5.8
10	" 12	S.E.	15	580.12	.52	.79	.48	.66	178,900	14B	M	10,360	10B	M	10,340	10,350	5.8
11	Sept. 1	N.E.	8	(piles) .19	.62	.86	.36	.41	189,400	15B	Q	10,770	14B	Q	10,850	10,810	5.7
12	" 1	N.E.	8	.28	.73	.91	.40	.43	192,400	14B	Q	11,150	15B	Q	10,770	10,960	5.7
13	" 1	N.E.	8	.29	.72	.92	.39	.42	192,800	14B	Q	10,910	15B	Q	10,780	10,840	5.6
14	" 1	N.E.	10	.22	.67	.87	.38	.40	190,700	14B	Q	11,080	10B	Q	10,960	11,020	5.8
15	Oct. 6	S.E.	8	579.86	.62	.86	.19	.26	178,600	10B	S	10,500	14B	S	10,330	10,420	5.8
16	" 6	S.E.	10	.69	.18	.44	.16	.27	172,100	14B	S	10,150	10B	S	10,160	10,160	5.9
17	" 6	S.E.	10	580.13	.46	.66	.26	.37	188,100	15B	S	10,620	10B	S	10,530	10,580	5.6
18	Nov. 20	W.	10	579.84	579.98	* .23	575.73	574.83	178,300	14B	U	10,970	10B	U	10,980	10,930	6.1
19	" 25	W.N.W.	20	.57	.99	* .23	.76	.83	179,400	14B	U	11,040	15B	U	11,079	11,060	6.2
20	" 25	N.W.	30	.65	579.03	.25	.73	.83	182,300	14B	U	11,030	15B	U	11,040	11,040	6.1

*Elevations supplied.

Williams Exhibit 23.

Williams Ex. 23

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Summary of Discharge
Section Bridge

Sheet 17
(37 Sheets)
Table 15
W. S. Richmond, Jun. Engr.
April, 1911

Number	Date 1910	Time of Day	Meter	Rating	Wind		WATER SURFACE ELEVATIONS						Discharge	Discharge of River	Percent of Flow
					Dir.	Vel.	Fort Gratiot	G. T. R.	Dry Dock	Roberts Landing	Herons Island	St. Clair Flats			
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q
							(shore)								
1	May 26	11:00-11:30	10B	M	N.W.	10	580.25	579.78	578.96	576.50	576.02	575.52	580	188,100	.31
2	May 26	12:40-13:00	10B	M	S.W.	15	.44	.82	.98	.48	.00	.51	623	191,600	.32
3	May 26	13:10-13:30	10B	M	N.W.	15	.46	.77	.91	.43	575.96	.42	618	191,700	.32
4	May 26	14:00-14:40	15B	L	N.W.	18	.43	.71	.89	.43	.95	.50	615	191,400	.32
5	May 26	16:40-17:30	15B	L	N.W.	18	.49	.76	.91	.44	.96	.50	667	191,500	.32
6	July 13	8:20- 9:00	71B	K	N.W.	12	.52	.84	579.01	.52	*576.06	.64	454	193,900	.23
7	July 13	9:20-10:50	10B	M	N.W.	13	.51	.79	.00	.51	* .06	.64	396	193,500	.21
8	July 13	10:40-12:30	14B	M	N.W.	12	.54	.66	578.88	.50	* .06	.65	426	187,900	.23
9	July 13	13:40-14:30	14B	M	N.W.	12	.43	.69	579.01	.53	* .07	.65	415	190,400	.22
							(piles)								
10	Sept. 2	8:00- 8:50	15B	Q	N.E.	4	.00	.44	578.69	.30	575.85	.44	306	181,900	.17
11	Sept. 2	9:20- 9:50	15B	Q	N.E.	4	.05	.52	.73	.33	.88	.44	394	183,800	.16
12	Sept. 2	10:50-11:10	14B	Q	N.E.	4	.09	.50	.70	.33	.89	.44	290	181,900	.16
13	Oct. 7	12:40-13:10	71B	K	N-N.W.	6	.02	.51	.73	.21	* .77	.35	343	184,500	.19
14	Oct. 7	13:00-13:30	71B	K	N-N.W.	6	.06	.53	.71	.25	* .78	.36	344	185,700	.19
15	Oct. 7	13:40-14:20	10B	S	N-N.W.	4	.07	.51	.72	.23	* .78	.36	356	186,000	.19
16	Oct. 7	14:30-15:50	14B	S	N-N.W.	3	.00	.48	.70	.22	* .77	.36	333	183,500	.18
17	Nov. 25	14:30-16:30	14B	U	N.W.	20	579.66	.10	.30	575.84	.32	576.36	409	182,000	.23
18	Nov. 25	15:30-16:10	71B	K	N.W.	20	.76	.19	.37	.84	.33	.84	422	186,000	.23

*Elevations Supplied.

U. S. LAKE SURVEY.
HYDRAULICS OF ST. CLAIR RIVER.
Summary of Discharge.
Section Bassett.

Sheet 18.
(37 Sheets)
Table 17
W. S. Richmond, Jun. Engr.
April, 1911.

Number	Date 1910	Wind		Water Surface Elevations						Discharge of River	Channel Discharge						Mean Channel Discharge	Percent of Flow
		Dir.	Vel.	Fort Gratiot	G.T.R.	Dry Dock	Roberts Landing	Hersco Island	St. Clair Flats		Meter	Rating	Discharge	Meter	Rating	Discharge		
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T
1	June 8	S.W.	2	(Shore) 580.38	579.69	578.02	576.53	576.04	575.60	187,700	1B	K	11,633	14B	K	11,311	11,470	6.1
2	8	S.W.	2	.33	.66	.90	.51	.04	.58	185,800	1B	K	11,842	713	K	11,724	11,780	6.3
3	9	N.E.	4	.24	.59	.82	.45	.02	.68	182,800	10B	M	11,304	14B	K	11,239	11,320	6.3
4	9	N.E.	6	.26	.65	.88	.50	.04	.67	183,700	10B	M	11,550	15B	L	11,627	11,590	6.3
5	9	N.E.	6	.31	.69	.90	.51	.02	.68	185,300	712	K	11,336	15B	L	11,330	11,330	6.1
6	July 14	S.	6	.19	.58	.84	.46	.04	.65	181,700	14B	M	11,386	10B	M	11,156	11,270	6.2
7	14	S.W.	6	.23	.57	.84	.47	.02	.65	182,100	14B	M	11,398	15B	M	11,780	11,590	6.4
8	14	S.	12	.19	.58	.87	.48	.03	.64	182,300	712	K	11,403	15B	M	11,646	11,530	6.3
9	Aug. 30	S.E.	15	(Piles) 579.73	.22	.50	.26	575.86	.46	171,500	14B	Q	10,150	15B	Q	10,005	10,080	5.9
10	30	S.E.	15	.65	.34	.57	.30	.87	.45	176,100	15B	Q	10,154	14B	Q	10,222	10,200	5.8
11	30	S.E.	12	.77	.26	.56	.28	.84	.44	173,500	15B	Q	9,574	14B	Q	9,837	9,710	5.6
12	30	S.E.	12	.84	.36	.61	.29	.84	.44	176,100	15B	Q	9,977	14B	Q	10,020	10,000	5.7
13	Oct. 14	S.W.	4	.91	.43	*.66	*.16	.74	.27	182,300	14B	S	11,192	15B	S	11,211	11,200	6.1
14	14	S.W.	1	.90	.36	*.59	*.16	.74	.28	181,700	10B	S	10,801	15B	S	10,779	10,790	5.9
15	14	S.W.	3	.88	.36	*.58	*.18	.76	.28	182,700	15B	S	11,230	10B	S	11,081	11,150	6.1
16	14	N.E.	3	580.01	.44	*.66	*.18	.75	.29	185,400	713	S	10,687	10B	S	10,603	10,640	5.7
17	Nov. 28	N.W.	10	579.22	578.74	577.97	575.65	*.25	574.99	166,400	15B	U	10,239	10B	U	10,373	10,350	6.3
18	28	N.W.	10	.25	.76	578.01	.68	*.30	.88	166,700	15B	U	10,949	14B	U	10,108	10,180	6.1
19	28	N.W.	10	.39	.86	.05	.70	.25	.89	171,500	15B	U	10,706	14B	U	10,741	10,720	6.3

*Elevations supplied.

Williams Ex. 23.

U. S. LAKE SURVEY.
HYDRAULICS OF ST. CLAIR RIVER.
Summary of Discharge.
Section South East Bend.

Sheet 19
(37 Sheets)
Table 19
W. S. Richmond, Jun. Engr.
April, 1911

Number	Date 1910	Wind		Water Surface Elevations						Discharge of River	Channel Discharge						Mean Channel Discharge	Percent of Flow
		Dir.	Vel.	Fort Gratiot	G.T.R.	Dry Dock	Roberts Landing	Herons Island	St. Clair Flats		Meter	Rating	Discharge	Meter	Rating	Discharge		
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T
1	June 2	S.E.	6	(Shore) 580.41	579.72	579.94	*576.41	575.93	575.58	191,100	14-B	K	55,530	1-B	K	56,050	55,790	29.3
2	" 3	E.	2	.42	.77	.99	*.44	.97	.59	191,600	15-B	L	56,500	10-B	M	56,600	56,550	29.6
3	" 3	N.E.	13															
3	" 3	N.E.	20	*.67	.98	*.95	*.50	576.65	.64	183,400	14-B	K	54,240	15-B	L	57,480	57,100	30.3
4	" 3	N.	13	*.44	.79	*.82	*.50	.08	.67	190,300	10-B	M	54,710	14-B	K	54,970	54,840	28.8
5	July 19	N.W.	8	.29	.64	.93	.50	.07	.55	185,200	15-B	M	55,260	10-B	M	54,280	54,870	29.6
		S.W.	16															
6	" 19	S.-W.	15-8	.39	.66	.96	.52	.07	.64	185,300	14-B	M	55,910	15-B	M	55,430	55,660	30.0
7	" 20	S.W.	15-20	.60	.44	.73	.46	.05	.65	174,700	10-B	M	52,240	14-B	M	53,640	52,440	30.0
8	" 20	S.-W.	13-15	.08	.47	.77	.47	.04	.64	176,800	10-B	M	52,420	15-B	M	53,210	52,820	29.9
9	Aug. 24	S.-S.W.	20	(Piles) 579.66	.22	.49	.27	572.86	.47	168,700	14-B	Q	52,100	15-B	Q	51,980	52,040	30.8
10	" 24	S.S.E.	15	.55	.31	.57	.32	.90	.47	175,700	14-B	Q	52,120	15-B	Q	51,850	51,980	29.6
11	" 26	E.N.E.	15	580.19	.61	.81	.35	.68	.42	180,300	14-B	Q	56,980	15-B	Q	56,740	56,860	30.1
		N.E.	20															
12	" 29	N.-E.	15.8	.16	.90	.82	.36	.90	.43	188,600	15-B	Q	56,870	14-B	Q	57,420	57,140	30.3
13	Oct. 13	N.E.	4	579.33	578.96	.27	*.16	.60	.33	167,200	14-B	S	50,120	15-B	S	49,510	49,820	29.8
		S.E.	15															
14	" 13	S.-E.	13-15	.62	579.13	.37	*.17	.71	.33	170,600	15-B	S	51,250	14-B	S	50,120	50,680	29.7
15	" 13	S.E.	10	.57	.09	.41	*.16	.71	.30	169,300	15-B	S	53,280	10-B	S	51,430	51,840	30.7
16	" 14	S.S.W.	2	.93	.35	*.56	*.16	.75	.27	182,900	14-B	S	54,300	10-B	S	53,700	54,000	29.5
17	Nov. 26	N.	8	.67	.14	.25	575.75	.23	574.86	182,400	14-B	U	55,940	10-B	U	55,660	55,800	30.6
18	" 26	N.W.	4	.60	.12	.33	.76	.25	.86	183,100	14-B	U	55,760	15-B	U	56,270	56,020	30.6
19	" 26	W.	2	.51	.01	.24	.76	.26	.85	178,800	15-B	U	56,050	10-B	U	56,140	56,100	31.9

*Elevations supplied.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Summary of Discharge
Section M. C.

Number	Date 1910	Wind		Water Surface Elevations						Discharge of River	Channel Discharge						Mean Channel Discharge	Percent of Flow
		Dir.	Vel.	Fort Gratiot	G.T.R.	Dry Dock	Roberts Landing	Salt Block	St. Clair Flats		Meter	Rating	Discharge	Meter	Rating	Discharge		
A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T
1	May 20	S'ly	10	(Shore)						185,100	15B	L	32,180	1B	K	32,250	32,220	17.4
2	" 21	W.	25	580.25	579.59	578.77	576.39	575.34	575.49	209,300	15B	L	33,840	1B	K	33,920	33,880	16.2
3	" 21	W.	25	.01	.46	*579.06	.51	.36	.58	208,600	15B	L	32,220	14B	K	31,930	32,080	15.4
4	" 21	W.	20	.89	.90	.05	.49	.38	.58	203,600	10B	M	33,970	14B	K	32,840	33,400	16.4
5	" 21	S.W.	12	.76	.93	.03	.53	.90	.59	208,400	10B	M	34,600	1B	K	34,860	34,730	16.7
				.80	.98	.09	.51	" .90	.59									
6	July 18	N.N.E.	8	580.61	579.72	579.05	576.52	575.96	575.66	197,000	10B	M	34,440	14B	M	35,120	34,780	17.7
7	" 18	N.N.W.	20	.91	.52	.07	.51	.96	.63	208,300	14B	M	37,080	10B	M	35,700	36,390	17.5
8	" 18	N.N.W.	25	.85	.61	.06	.49	.93	.62	206,300	10B	M	34,880	15B	M	35,720	35,300	17.1
9	" 18	N.N.W.	25	.94	.57	.06	.50	.92	.63	209,800	10B	M	35,590	15B	M	35,830	35,710	17.0
10	Aug. 31	N.E.	15	(Piles)						190,200	15B	Q	34,120	14B	Q	34,630	34,380	18.0
11	" 31	N.E.	12	580.39	579.74	578.90	576.34	575.77	575.42	185,700	14B	QQQ	33,120	15B	QQQ	33,480	33,300	18.0
12	" 31	N.E.	10	.17	.61	.82	.32	.78	.43	189,500	10B	QQQ	32,630	15B	QQQ	32,790	32,660	17.3
13	" 31	N.E.	10	.24	.67	.87	.37	.82	.40	188,900	10B	QQQ	32,690	14B	QQQ	33,410	33,050	17.5
14	Oct. 11	S.W.	2	580.06	579.49	578.75	*576.23	575.72	575.37	183,900	14B	S	33,200	15B	S	33,240	33,220	18.2
15	" 12	N.	25	.32	.80	579.01	" .12	.70	.26	191,200	15B	S	35,330	14B	S	35,600	35,470	18.6
16	" 12	N.	25	.05	.04	578.80	" .13	.73	.27	184,800	15B	S	34,430	10B	S	34,200	34,320	18.6
17	" 12	N.	25	.04	.62	.83	" .12	.72	.26	184,600	14B	S	33,960	10B	S	33,330	33,650	18.2
18	Nov. 19	W.	4	579.74	579.17	578.35	576.84	576.30	*574.96	179,800	14B	U	32,080	10B	U	31,510	31,790	17.7
19	" 19	N.W.	8	.61	.06	.31	.32	.30	" .96	175,500	14B	U	31,610	10B	U	31,040	31,330	17.9
20	" 19	N.W.	8	.60	.04	.28	.61	.30	" .95	175,400	14B	U	31,940	15B	U	31,780	31,860	18.2

*Elevations Supplied.

Williams Exhibit 23.

U. S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Summary of Discharge
Section Salt Block

W. S. Richmond, Jun. Engr.
April, 1911

Number	Date 1910	Wind		Water Surface Elevations						Discharge of River	CHANNEL DISCHARGE						Mean Channel Discharge	Percent of Flow
		Dir.	Vel.	Fort Gratiot	G.T.R.	Dry Dock	Roberts Landing	Salt Block	St. Clair Flats		Meter	Rating	Discharge	Meter	Rating	Discharge		
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T
1	June 4	S.-W.	4	(shore)						197,500	14B	K	77,420	1B	K	79,170	78,300	41.7
		N.-E.	8	680.36	679.60	678.92	678.61	678.04	678.08									
2	June 6	S.W.	4	.26	.71	.94	.55	.97	.70	186,700	1B	K	73,680	10B	M	77,380	77,970	41.7
3	June 6	S.-W.	4	.42	.77	.99	.54	.98	.70	189,300	10B	M	80,630	15B	L	80,270	80,300	42.4
4	June 6	N.-W.	8	.32	.72	.93	.54	.96	.70	187,800	10B	M	73,250	15B	K	79,050	76,700	41.8
5	June 7	S.-W.	10-16	.46	.80	679.01	.55	.94	.69	190,600	15B	L	78,540	14B	K	76,460	77,500	40.7
6	July 15	S.	1-5	680.22	679.80	678.87	678.47	678.06	678.04	183,000	10B	M	72,460	14B	M	73,630	72,540	39.6
7	July 15	W.	6	.25	.65	.92	.49	.96	.64	184,100	14B	M	73,600	10B	M	73,340	73,470	39.9
8	July 15	S.S.E.	6	.23	.64	.92	.51	.95	.65	185,000	14B	M	73,020	15B	M	74,510	73,760	39.9
9	July 16	S.-W.	4	.29	.55	.83	.45	.94	.65	183,300				10B	M	73,260	73,260	39.6
10	Aug. 26	N.-W.	10	(piles)	679.78	678.99	678.42	678.03	678.02	194,000	10B	Q	72,170	14B	Q	73,190	72,680	37.1
		S.-W.	8	680.28														
11	Aug. 26	S.-W.	8	.26	.68	.91	.49	.96	.62	191,500	14B	Q	70,370	10B	Q	70,260	70,320	36.7
12	Aug. 27	W.S.W.	1	.03	.46	.73	.23	.84	.43	183,100	713 Price	Q	70,060	15B	Q	70,440	70,700	38.6
13	Aug. 27	S.	3	.02	.45	.71	.25	.83	.43	182,800	10B	Q	69,160	15B	Q	70,360	69,760	38.2
14	Oct. 10	S.W.	3-5	679.94	679.39	*678.63	*678.22	678.00	678.36	181,600	15B	S	71,670	10B	S	71,200	71,440	39.4
15	Oct. 10	S.	3	.90	.39	.68	* .23	.71	.27	179,700	15B	S	69,370	14B	S	69,570	69,610	38.7
16	Oct. 10	S.	1	.81	.31	.59	* .19	.72	.27	178,400	15B	S	69,470	14B	S	68,850	68,160	38.7
17	Oct. 11	S.-S.W.	5-7	680.04	.47	.69	* .23	.76	.29	184,400	10B	S	71,040	15B	S	72,240	71,640	38.9
18	Oct. 11	S.-S.W.	6	.10	.52	.76	* .22	.74	.36	187,200	10B	S	73,330	713 Price	S	73,260	73,440	39.2
19	Nov. 21	S.W.	12-20	679.20	678.73	677.97	678.00	678.32	674.23	196,000	14B	U	66,130	15B	U	65,990	66,060	40.2
20	Nov. 22	W.	4	.27	.84	*678.37	.74	.23	.84	171,800	15B	U	71,960	10B	U	Reject	71,960	41.9
21	Nov. 23	W.	6	.51	.96	* .39	.72	.21	.82	169,900	14B	U	71,180	10B	U	Reject	71,180	41.9

*Elevations Supplied.

Sheet 22
(37 Sheets)

U.S. ENGR. SURVEY

Williams Ex. 23. HYDRAULICS OF ST. CLAIR RIVER TABLE 24

PERCENTAGE DISCHARGE IN CHANNELS OF DELTA.

W. S. RICHARDS, Asst. Engr.
APRIL 15, 1911.

Month	Bay	Sawmill	Mud	South	Middle	North	Total
June	6.0	0.2	0.1	29.5	16.9	47.7	100.1
July	5.8	0.3	0.2	28.9	17.3	39.8	99.3
Aug.	5.7	0.2	0.2	30.2	17.7	37.6	97.6
Oct.	5.8	0.3	0.2	29.9	18.4	38.8	99.3
Nov.	6.1	0.3	0.2	31.0	17.9	41.4	102.7
Mean	5.9	0.1	0.2	30.1	17.8	39.9	99.7

Williams Ex 23

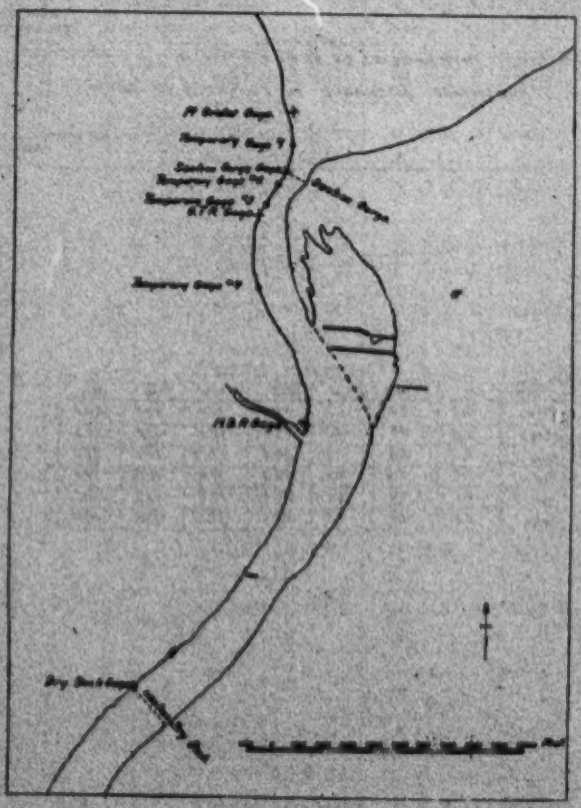
Sheet 23
(37 Sheets)
PLATE 8

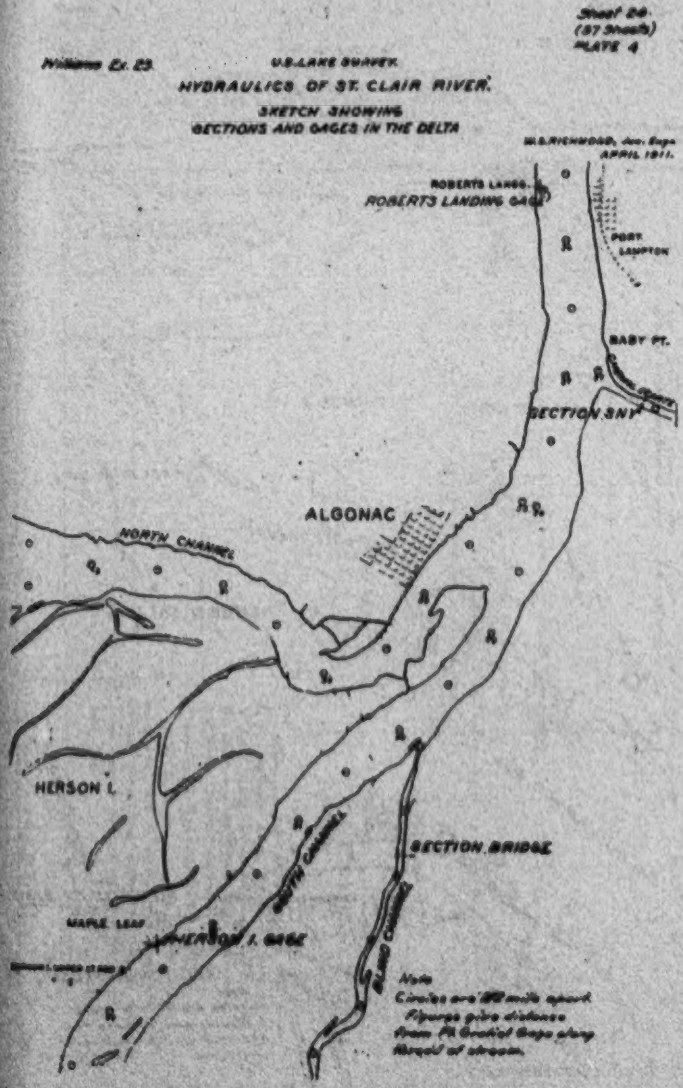
U.S. LAKE SURVEY

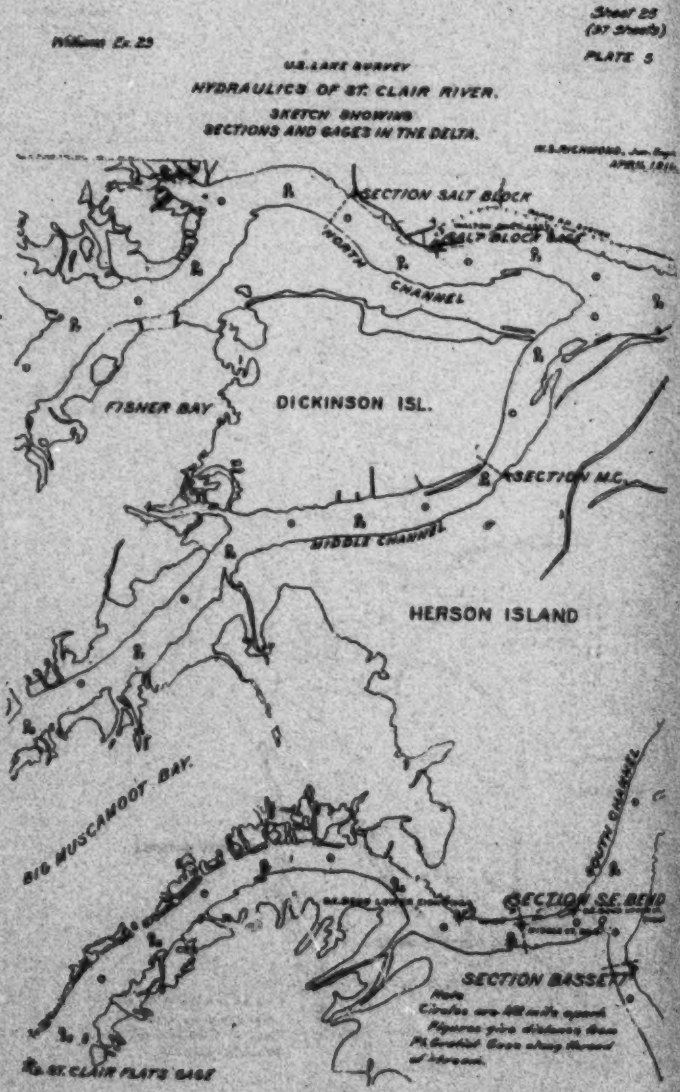
HYDRAULICS OF ST. CLAIR RIVER.

Sketch showing Sections and Gages at Head of River

APRIL, 1911.




Sheet 24
(37 Sheets)
PLATE 4
Williams Ex. 23.
U.S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER.
SKETCH SHOWING
SECTIONS AND GAGES IN THE DELTA
W.S. RICHWOOD, Asst. Engr.
APRIL 1911.
ROBERTS LANDG.
ROBERTS LANDING GAGE
PORT LAMBTON
BABY PT.
SECTION 3N1
ALGONAC
NORTH CHANNEL
HERSON I.
SECTION BRIDGE
SOUTH CHANNEL
MAPLE LEAF
HERSON I. GAGE
Note
Elevations are USE mean tide datum
Figures give distance
from Pt Grondal Gage along
thread of stream.


Sheet 23
(37 Sheets)
Williams Ex. 23
PLATE 5
U.S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER.
SKETCH SHOWING
SECTIONS AND GAGES IN THE DELTA.
APRIL, 1911.
SECTION SALT BLOCK
SALT BLOCK GAGE
NORTH CHANNEL
FISHER BAY
DICKINSON ISL.
SECTION M.C.
DIBBLE CHANNEL
HERSON ISLAND
BIG MUSCAMOOT BAY.
SOUTH CHANNEL
SECTION S.E. BEND
SECTION BASSETT
Note
Circles are 400 mile square
Figures give distances down
Mt. Crushed Stone along thread
of stream.
ST. CLAIR FLATS GAGE

Sheet 56
(29 Sheets)

Williams Ex. 23¹

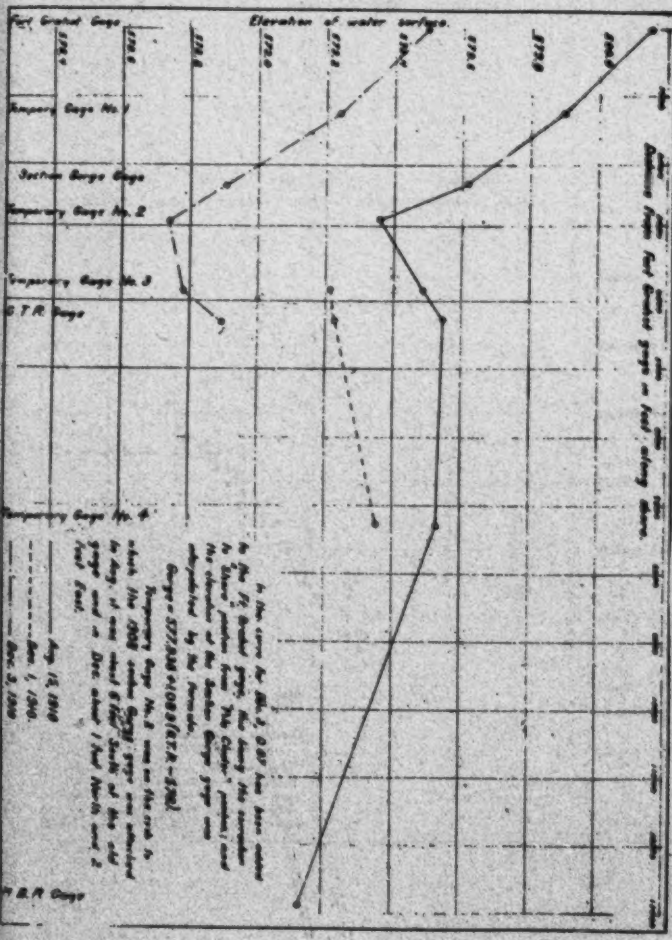
U.S. LAKE SURVEY

PLATE 7

HYDRAULICS OF ST. CLAIR RIVER

LOCAL SLOPES ALONG WEST BANK AT HEAD OF RIVER

W.S. RICHARDSON, Asst. Engr.
APRIL 1911.



Williams Ex 23

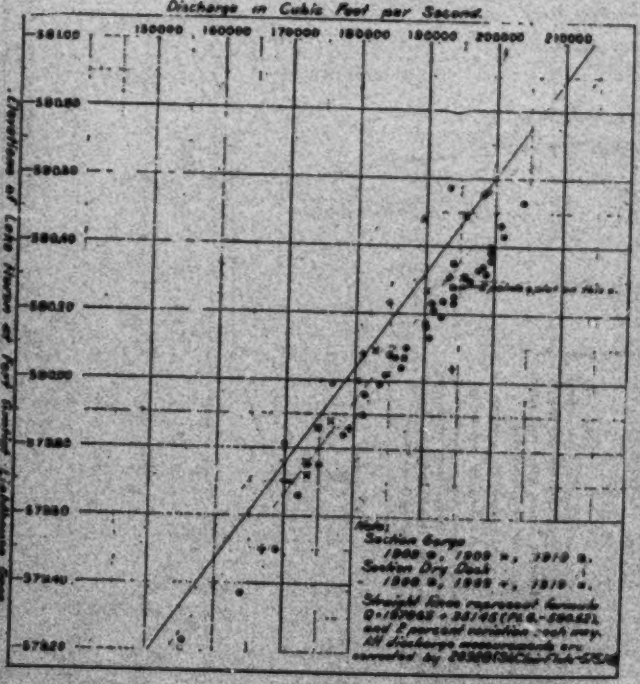
Sheet 27
(37 Sheets)
PLATE 18

U.S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER.

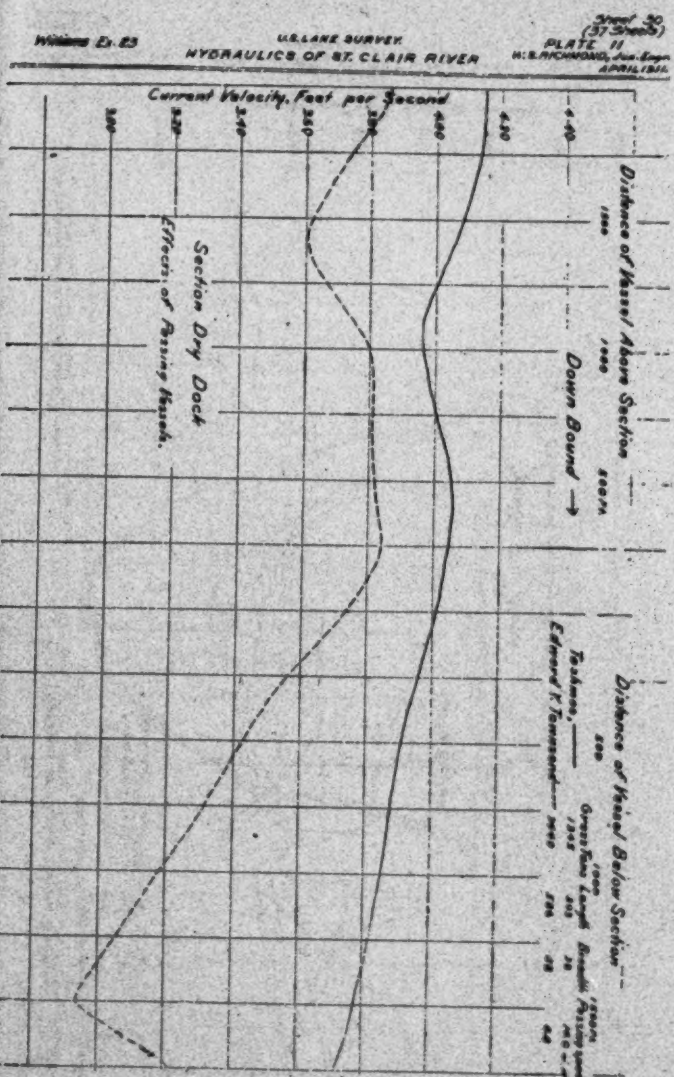
DISCHARGE OF ST. CLAIR RIVER
MEANS OF FIVE.

W.S. RICHMOND Jun. Engr.
APRIL, 1911



Williams Ex. 23.
U.S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Sheet 26
(37 Sheets)
PLATE 9
H.S.A. RICHMOND, Junr. Engr
APRIL 1911
Current Velocity, Feet per Second
Distance of Vessel Above Section
Down Bound
Distance of Vessel Below Section
Section Gorge
Effects of Passing Vessels.

Williams Ex. 23
U.S.LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Sheet 124
(37 Sheets)
PLATE 10
APRIL 1911
Current Velocity, Feet per Second
Distance at Head/ Above Section
Distance at Head/ Below Section
Section Gauge
Effects of Passing Vessels
← Up Bound
City of St. Ignace
J.S. Keefe
C.M. Starke
Ocklawaha


Williams Ex. 23
U.S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Sheet 30 (37 Sheets)
PLATE II
H. S. RICHARDSON, Asst. Engr.
APRIL 1911.
Current Velocity, Feet per Second
Distance of Vessel Above Section
Down Bound →
Distance of Vessel Below Section
Section Dry Dock
Effects of Passing Vessels.
Steamer, ——
Entered L. Tennessee
Gross Tons
Length
Breadth
Passing speed

Williams Ex. 23
U.S. LAKE SURVEY
HYDRAULICS OF ST. CLAIR RIVER
Sheet 2
(37 Sheets)
PLATE 18
U.S. RICHMOND, Asst. Engr.
APRIL 1911
Current Velocity, Feet per Second
Distance of Vessel Above Section
Distance of Vessel Below Section
Tacoma
Dramico
Minnie
Ramapo
Length
Beam
Draft
Section Dry Dock
Effects of Passing Vessels
Up Bound

Williams Ex. 23

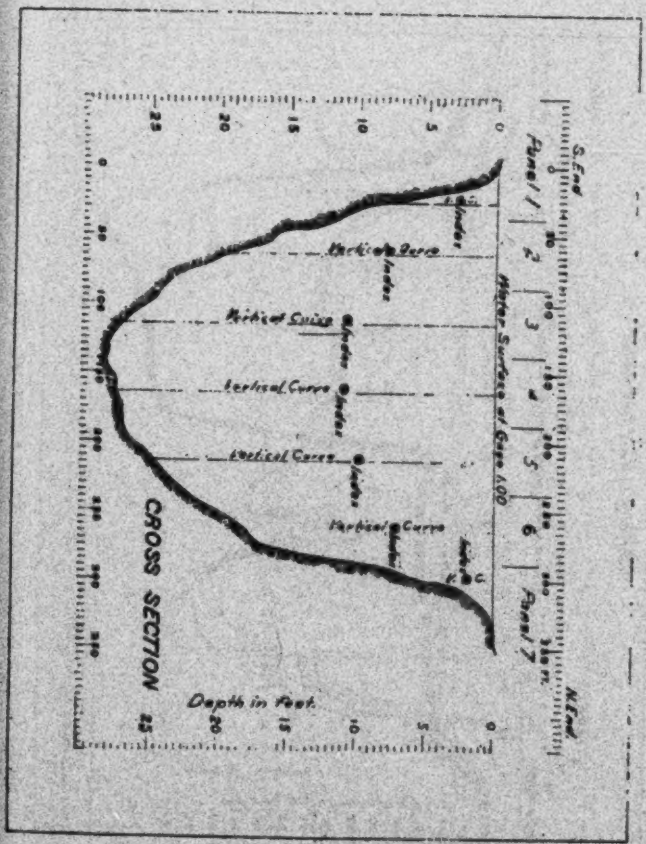
U.S. LAKE SURVEY

Sheet 32
(37 Sheets).
PLATE 13

HYDRAULICS OF ST. CLAIR RIVER

CHENAL ECARTE.
SECTION 8 N.Y.

W.S. RICHMOND, Jun. Engr.
APRIL 1911



Sheet 33
(97 Sheets)

Williams Ex 23.

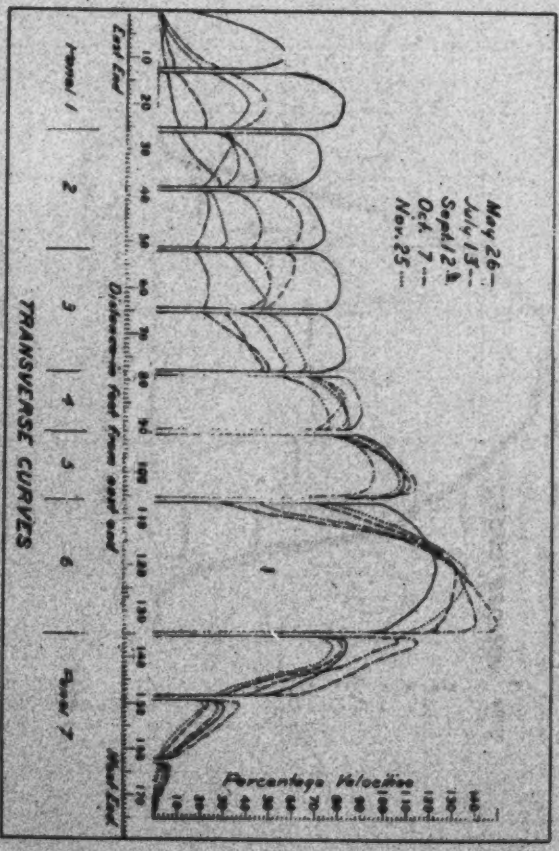
PLATE 18

U.S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

BLIND CHANNEL
SECTION BRIDGE

W. S. RICHMOND, Asst. Engr.
APRIL 1911.



Williams Ex. 28.

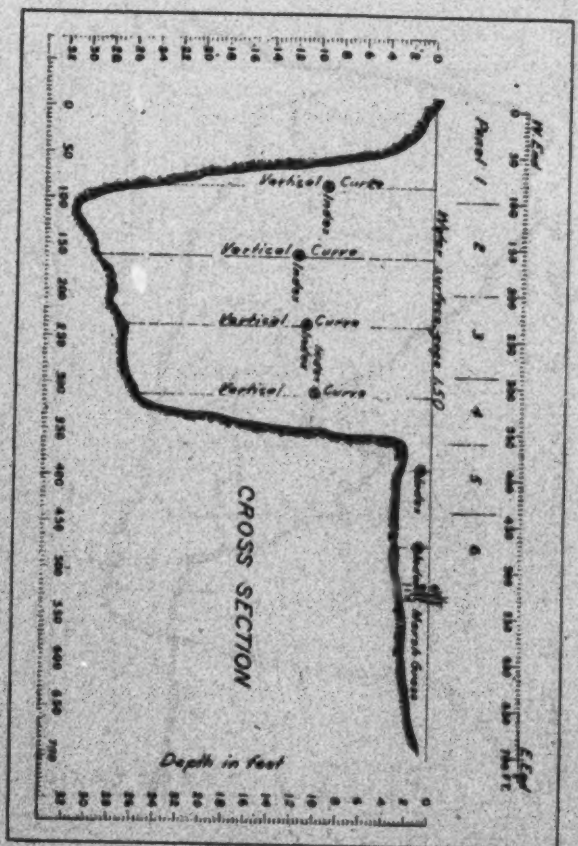
Sheet 34
(37 Sheets)
PLATE 19

U.S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

BASSETT CHANNEL.
SECTION BASSETT.

W.B. RICHMOND Asst. Engr.
APRIL 1911.



Williams Ex. 23.

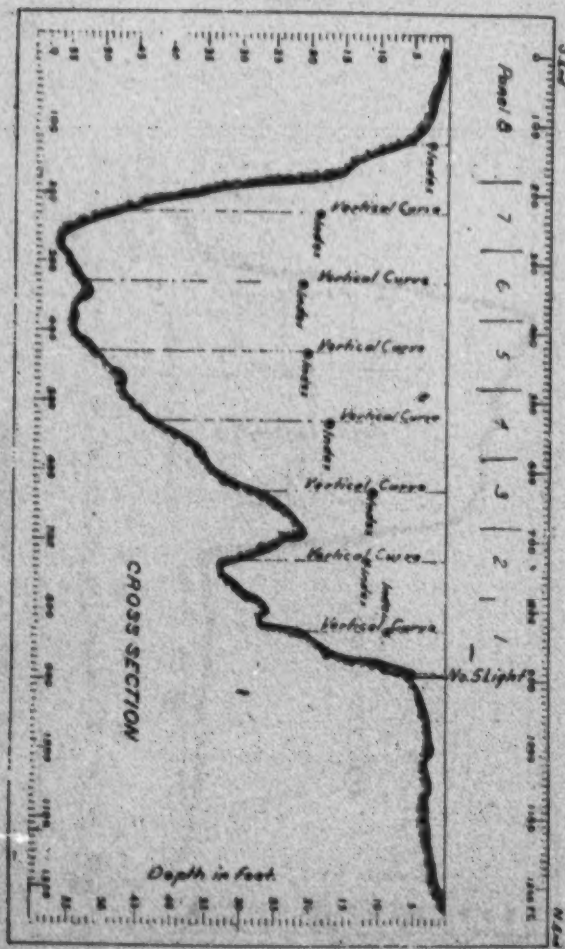
U.S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

SOUTH CHANNEL
SECTION S.E. BEND.

PLATE 22
Sheet 35
(37 Sheets)

H.S. RICHMOND Asst. Engr.
APRIL 1911.



Williams Ex. 23

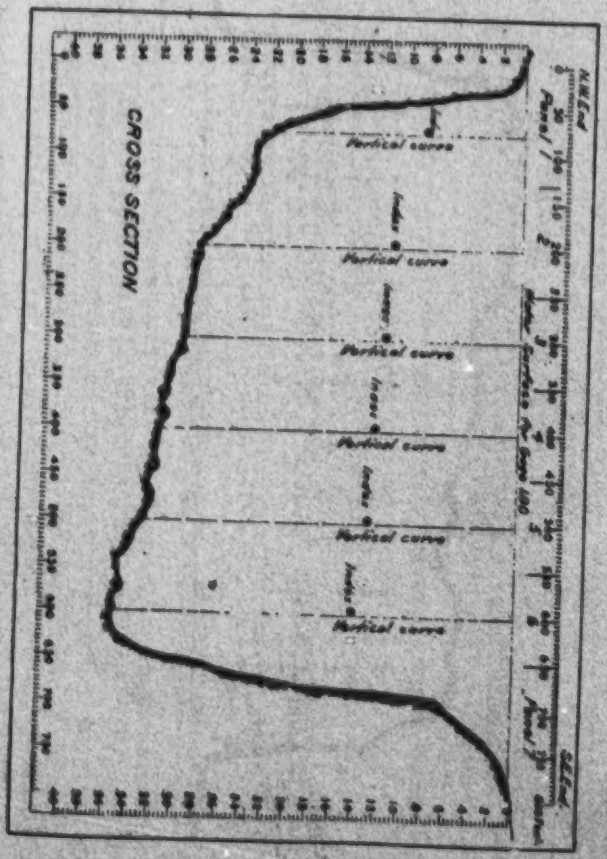
U.S. LAKE SURVEY.

HYDRAULICS OF ST. CLAIR RIVER

MIDDLE CHANNEL
SECTION MC.

PLATE E 5
Sheet 36.
(37 Sheets.)

W.S. RICHARDSON Jun. Engr.
APRIL, 1911.



Sheet 37
(37 Sheets)
PLATE 28

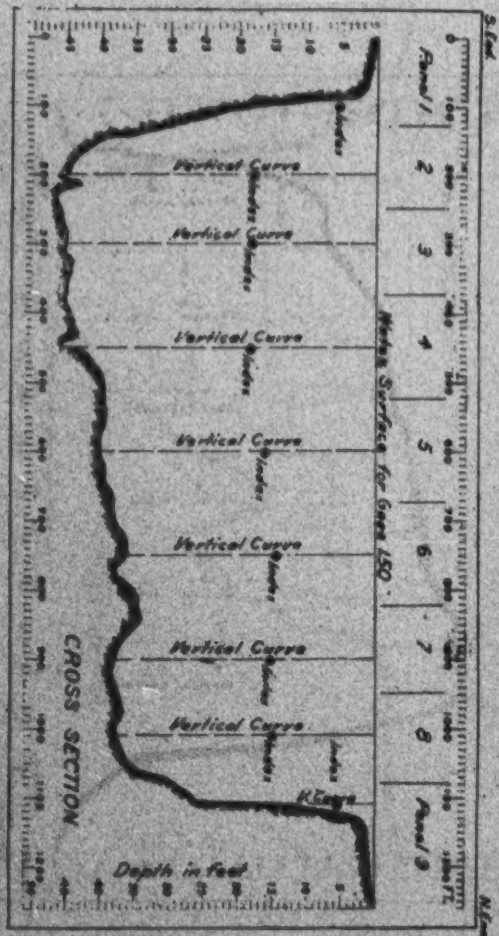
Williams Ex. 23

U.S. LAKE SURVEY

HYDRAULICS OF ST. CLAIR RIVER

NORTH CHANNEL
SECTION SALT BLOCK

W.D. RICHMOND, Asst. Engr.
APRIL 1911.



Williams Ex. 24.

Table No. 1
SUMMARY OF DISCHARGES.
International Bridge Section.
NIAGARA RIVER.

Sheet 1
(5 Sheets)

Levels of 1903.
F. B. M. Buffalo Light House, 580,101.
F. B. M. International Bridge, No. 2,562,258.

F. C. Shenehon,
U. S. Asst. Engineer
1906

Measurement No.	Date	Elevation of Water Surface Above Mean Tide, New York: Lake Erie Level	Elevation of Water Surface Above Mean Tide, New York: Section Gage at Bridge	Fall Lake Erie to Bridge	Change at Lake During Measurement, Feet: Rise	Change at Lake During Measurement, Feet: Fall	Wind: Direction from which it Blows	Wind: Approx. Velocity Miles per Hour	Discharge Cubic feet per Second	Rating No. Used: Meter I.S.B.	Rating No. Used: Meter I.S.A.	Weighted Mean Index Velocity	Percentage Residuals
	1903												
1	Sept. 10	571.44	566.97	4.48	0.03	0.23	N.E.	8	180,600	1		5.14	−2.2
2	12	572.03	567.39	4.67	0.06	0.23	S.W.	6	195,800	1		5.84	−0.6
3	13	571.96	567.23	4.63	0.00	0.21	S.W.	8	195,000	1		5.81	−0.3
4	15	572.01	567.26	4.63	0.07	0.11	S.W.	9	195,500	1		5.81	−0.6
5	15	572.16	567.42	4.74	0.44	0.02	S.W.	9	198,900	1		5.91	−0.4
6	17	571.74	567.19	4.55	0.06	0.13	S.W.	6	188,500	1		5.68	−1.2
7	17	571.75	567.16	4.59	0.13	0.06	S.W.	7	190,400	1		5.72	−0.4
8	20	571.96	567.23	4.71	0.13	0.20	N.W.	5	195,000	1		5.84	−0.3
9	20	571.79	567.20	4.59	0.15	0.06	N.E.	5	191,200	1		5.73	−0.3
10	23	571.70	567.13	4.57	0.03	0.12	S.W.	10	189,100	1		5.67	−0.6
11	23	571.77	567.13	4.64	0.23	0.07	S.W.	12	191,100	1		5.74	−0.2
12	24	571.76	567.06	4.70	0.06	0.10	N.E.	6	193,800	1		5.84	+1.1
13	24	572.24	567.34	4.90	0.10	0.12	N.E.	4	206,800	1		6.15	+3.5
14	27	572.35	567.38	4.97	0.10	0.01	N.W.	4	208,900	1		6.14	+1.4
15	27	572.33	567.43	4.90	0.02	0.13	N.W.	6	208,200	1		6.15	+1.5
16	29	571.85	567.22	4.63	0.03	0.15	S.W.	7	188,900	1		5.65	−2.2
17	29	571.73	567.15	4.58	0.04	0.15	S.W.	7	187,400	1		5.62	−1.7
18	Oct. 1	571.42	566.87	4.55	0.11	0.09	S.E.	3	181,900	1		5.53	−1.1
19	1	571.43	566.80	4.59	0.22	0.04	S.E.	2	184,800	1		5.61	−0.2
20	4	571.66	567.04	4.59	0.11	0.20	S.E.	3	186,700	1		5.66	−0.2
21	4	571.76	567.08	4.68	0.16	0.01	S.	2	190,100	1		5.72	−0.6
22	6	571.41	566.88	4.53	0.00	0.00	N.E.	6	182,200	1		5.54	−0.9
23	6	571.08	566.94	4.72	0.28	0.04	N.E.	6	188,000	1		5.71	−0.5
24	8	571.72	567.02	4.67	0.13	0.08	N.	5	186,900	1		5.68	−0.8
25	8	571.72	567.06	4.67	0.10	0.10	N.	6	186,900	1		5.67	−0.9
26	11	572.04	567.34	4.70	0.00	0.74	S.W.	18	212,500	1		6.18	+1.0
27	11	571.90	567.61	4.38	0.08	0.32	S.W.	16	196,900	1		5.80	+0.3
28	12	571.57	566.93	4.62	0.12	0.07	E.	5	188,500	1		5.71	+0.7
29	13	571.64	566.90	4.68	0.14	0.11	E.	8	190,400	1		5.76	+0.9
30	15	571.80	567.28	4.64	0.21	0.03	N.W.	8	188,900	1		5.64	−1.7
31	15	572.03	567.32	4.71	0.14	0.04	N.W.	6	193,500	1		5.76	−1.8
32	17	571.14	566.67	4.47	0.02	0.03	S.E.	8	183,200	1		5.51	+2.9
33	17	571.02	566.56	4.44	0.08	0.16	E.	5	175,600	1		5.41	0.0
34	17	570.79	566.36	4.43	0.04	0.10	S.E.	10	172,300	1		5.40	+1.7
35	17	570.64	566.29	4.35	0.01	0.23	S.E.	10	169,200	1		5.27	+0.8
36	19	571.41	566.96	4.45	0.42	0.05	S.W.	10	180,300	1		5.45	−2.0
37	21	571.61	567.02	4.59	0.02	0.21	S.W.	12	184,900	1		5.58	−1.7
38	21	571.61	567.03	4.58	0.02	0.23	S.	12	186,700	1		5.73	+0.6
39	22	.....	566.87	.....	.....	.....	S.W.	30	234,500	1		6.27	.....
40	23	.....	567.07	.....	.....	.....	W.	12	194,900	1		5.96	.....
41	25	571.66	567.05	4.61	0.07	0.06	S.W.	10	189,000	1		5.68	0.0
42	25	571.68	567.06	4.62	0.06	0.03	S.W.	10	192,200	1		5.80	+1.4
43	27	572.22	567.74	4.48	0.46	0.30	N.W.	12	201,000	1		5.88	−1.3
44	27	572.01	567.61	4.30	0.06	0.13	N.W.	12	209,600	1		5.87	−0.1
45	Nov. 1	572.29	567.39	4.90	0.00	0.37	S.S.W.	14	207,100	1		6.15	+2.2
46	1	571.97	567.27	4.70	0.16	0.15	S.W.	14	195,800	1		5.95	0.0
47	1	571.86	567.36	4.50	0.11	0.02	W.	10	194,900	1		5.80	+0.8
48	2	571.82	567.25	4.57	0.07	0.22	W.	12	193,000	1		5.76	+0.1
49	4	571.60	566.93	4.67	0.07	0.06	S.	10	188,000	1		5.71	0.0
50	4	571.53	566.89	4.64	0.01	0.23	S.	10	188,900	1		5.67	+0.3
51	4	571.47	566.78	4.69	0.12	0.07	S.	8	187,600	1		5.72	+1.4
52	4	571.44	566.77	4.67	0.05	0.06	S.	7	185,700	1		5.67	+0.6
53	9	570.11	565.96	4.15	0.60	0.46	N.E.	8	155,600	1		4.92	−0.9
54	9	570.14	565.71	4.43	0.45	0.27	N.E.	12	157,200	1		5.02	−0.2
55	9	.....	565.51	.....	.....	.....	N.E.	10	163,200	1		5.18	.....
56	10	570.00	565.58	4.42	0.18	0.00	N.E.	10	154,100	1		4.95	−0.4
57	10	570.03	565.60	4.43	0.07	0.34	E.N.E.	12	154,500	1		4.98	−0.6
58	10	570.34	565.65	4.69	0.67	0.08	E.N.E.	10	161,600	1		5.18	+1.2
59	15	.....	566.00	.....	.....	.....	S.W.	20	238,100	1		6.61	.....
60	15	.....	566.21	.....	.....	.....	S.W.	20	238,000	1		6.34	.....
61	21	571.87	566.97	4.90	0.10	0.12	S.E.	3	197,100	1		5.96	+1.8
62	21	571.66	566.91	4.74	0.00	0.10	S.E.	4	190,000	1		5.78	+0.6
63	22	571.79	566.85	4.94	0.05	0.08	S.E.	10	191,700	1		5.83	−0.1
64	23	571.66	566.90	4.76	0.02	0.27	S.E.	10	198,800	1		5.87	+3.4

See Table No. 3.

Williams Ex. 24

Table No. 1

SUMMARY OF DISCHARGES
International Bridge Section
NIAGARA RIVER

Sheet 1 (5 Sheets)

Levels of 1903
P. B. M. Buffalo Light House, 600.101
P. B. M. Int'n'l Bridge No. 2, 582.258

F. C. Shenehon
U. S. Asst. Engineer

Reference No. of Measurement	Date	Elevation of Water Surface Above Mean Tide, New York: Lake Erie Level	Elevation of Water Surface Above Mean Tide, New York: Section Gage at Bridge	Fall Lake Erie to Bridge	Change at Lake During Measurement Feet: Rise	Change at Lake During Measurement Feet: Fall	Wind: Direction from Which it Blows	Wind: Approx. Velocity Miles per Hour	Discharge Cubic Feet per Second	Rating No. Used: Meter L.S. 2B	Rating No. Used: Meter L.S. 4A	Weighted Mean Index Velocity	Percentage
	1902												
69	Nov. 22	572.79	567.81	4.98	0.07	0.06	N. W.	8	214,900	1		6.27	-4.5
70	23	572.82	567.72	5.10	0.25	0.24	W.	7	208,500	1		6.12	+2.1
71	23	571.44	566.69	4.75	0.14	0.02	S.E.	10	182,900	1		5.60	-2.8
72	26	571.43	566.69	4.74	0.06	0.12	S.E.	10	183,500	1		5.62	-4.4
73	26	571.74	566.85	4.89	0.09	0.03	N.E.	8	192,400	1		5.85	+2.6
74	28	571.54	566.77	4.77	0.04	0.04	N.W.	5	187,500	1		5.72	+4.8
75	28	571.51	566.53	4.98	0.38	0.04	N.W.	4	192,000	1		5.86	+0.3
76	29	571.46	566.74	4.72	0.05	0.08	S.E.	3	188,500	1		5.76	+2.0
77	29	571.56	566.77	4.79	0.20	0.10	S.E.	3	186,500	1		5.69	-4.1
78	29	571.63	566.80	4.83	0.26	0.06	E.	5	188,100	1		5.72	-4.3
79	Dec. 1	572.01	567.06	5.05	0.07	0.18	W.	18	221,200	1		6.43	+1.1
80	1	572.07	567.05	5.02	0.17	0.15	N.W.	20	217,600	1		6.32	-4.1
81	1	572.52	567.52	4.90	0.24	0.15	N.W.	20	218,200	1		6.33	+0.4
82	1	572.00	567.81	4.89	0.13	0.23	W.	20	215,000	1		6.26	+1.6
83	6	572.50	567.37	5.13	0.07	0.14	S.W.	20	215,600	1		6.41	+4.0
84	7	573.00	568.43	5.25	0.04	0.26	W.	20	234,500	1		6.66	+4.1
85	7	573.10	568.26	4.82	0.17	0.27	W.	15	222,600	1		6.39	+4.1
86	8	573.05	568.01	5.04	0.14	0.05	W.	20	219,400	1		6.35	+4.1
87	8	573.00	567.97	5.03	0.04	0.04	W.	20	218,800	1		6.35	+4.0
88	10	573.80	568.74	5.15	0.15	0.04	W.	25	238,000	1		6.69	+4.1
89	10	573.93	568.72	5.19	0.09	0.15	W.	30	240,900	1		6.78	+0.6
90	10	573.70	568.62	5.08	0.15	0.11	W.	30	231,300	1		6.54	-1.3
	1899												
91	Feb. 7	571.44	566.98	4.86	0.00	0.04	N.E.	10	178,600	1	See Table No. 2.	5.84	-4.2
92	8	571.58	566.95	4.83	0.04	0.00	N.W.	16	180,500	1		5.85	-4.7
93	14	571.24	567.23	4.12	0.00	0.13	W.	18	161,500	1		5.22	-11.5
94	15	571.39	567.21	3.98	0.03	0.00	S.W.	20	168,900	1		5.49	-4.9
95	15	571.23	567.20	4.03	0.00	0.04	S.W.	18	168,700	1		5.50	-7.3
96	15	571.23	567.17	4.15	0.01	0.00	S.W.	24	172,900	1		5.70	-4.4
97	15	571.23	567.03	4.20	0.00	0.00	W.	24	177,100	1		5.83	-0.9
98	16	571.24	567.18	4.06	0.02	0.00	S.	6	169,400	1		5.56	-4.6
99	16	571.24	567.15	4.09	0.01	0.01	S.W.	6	169,900	1		5.56	-4.7
100	17	571.23	566.99	4.04	0.01	0.02	W.	6	179,700	1		5.89	-1.3
101	17	571.20	566.98	4.02	0.01	0.01	W.	6	177,300	1		5.83	-2.2
102	17	571.23	566.97	4.06	0.04	0.02	W.	6	181,000	1		5.96	-0.6
103	24	571.23	566.80	4.39	0.03	0.02	W.	8	182,000	1		5.74	-0.7
107	24	571.40	566.90	4.50	0.01	0.02	W.	8	180,100	1		5.76	-1.9
108	25	571.23	566.70	4.53	0.00	0.11	N.W.	8	176,400	1		5.61	-2.3
109	25	571.27	566.71	4.56	0.06	0.24	E.	10	175,600	1		5.74	-1.3
110	25	571.17	566.56	4.61	0.00	0.10	S.E.	12	176,200	1		5.62	-1.6
111	25	571.26	566.54	4.71	0.06	0.05	S.E.	12	180,700	1		5.83	+0.3
112	Mar. 1	571.03	566.65	4.73	0.23	0.00	W.	8	186,100	1		5.90	-0.7
113	6	571.26	566.80	4.55	0.00	0.31	N.E.	8	174,900		5	5.52	-1.3
114	7	571.45	566.60	4.85	0.15	0.00	N.E.	16	181,000		5	5.80	-1.0
115	20	572.50	567.55	4.95	0.00	0.26	N.W.	13	194,000	2		6.08	-1.4
117	23	572.26	567.23	4.96	0.02	0.26	S.W.	12	219,400	2		6.86	-1.3
118	23	572.17	567.20	4.97	0.07	0.01	S.W.	10	217,600	2		6.83	-1.3
119	24	572.22	566.91	4.31	0.17	0.00	W.	26	185,200	2		5.90	-1.9
120	24	572.20	567.06	4.54	0.08	0.14	W.	28	193,800	2		6.12	-1.0
121	24	572.26	567.03	4.73	0.00	0.09	W.	22	196,600	2		6.10	-1.1
122	May 19	572.73	567.66	5.08	0.12	0.00	W.	15	213,300		5	6.51	+0.1
123	19	572.66	567.66	4.99	0.11	0.11	W.	15	210,800		5	6.43	+0.1
124	19	572.73	567.67	5.06	0.00	0.05	W.	15	212,800		5	6.48	0.0

Note:—
Nos. 116, 117, 118. Span 1 blocked with ice.
No. 114. Span 9 blocked with ice.
Nos. 91, 92, 100, 101, 102. Spans 1 and 9 blocked with ice.
Nos. 66 to 90, inclusive. Spans 1 and 9, and east half of Span 2 blocked.
No. 66. Discharge for Sta. 3½ is interpolated.
No. 120. Discharge for Span 2 is interpolated.
No. 119. Discharge for Spans 1 and 2, and Sta. 3½ interpolated.

Williams Ex. 24. Table No. 1 Sheet 3
(5 Sheets)

SUMMARY OF DISCHARGES.
International Bridge Section.
NIAGARA RIVER.

Levels of 1903.
P. B. M. Buffalo Light House, 590.101.
P. B. M. International Bridge No. 2, 562.258.

F. C. Shenehon,
U. S. Asst. Engr.
1906

Measurement No.	Date	Elevation of Water Surface Above Mean Tide, New York		Fall Lake Erie to Bridge	Change at Lake During Measurement, Feet		Wind		Discharge Cubic Feet per Second	Rating and Meter		Weighted Mean Index Velocity	Percentage Residuals
		Lake Erie Level	Section Gage at Bridge		Rise	Fall	Direction from which it Blows	Approx. Velocity Miles per Hour		Meter Used	Rating		
	1906												
a	July 16	572.37	567.55	4.82	0.13	0.04	S.E.	4	205,100	D. W. 12A.	Velocity=0.06+1.006 revolutions. No. 2.	6.06	+0.3
b	16	572.39	567.55	4.84	0.12	0.07	N.E.	6	206,100			6.08	+0.6
c	18	572.67	567.71	4.96	0.05	0.04	S.W.	14	214,000			6.23	+1.4
d	19	572.40	567.66	4.74	0.13	0.14	S.W.	16	201,600			5.93	−1.7
e	20	572.42	567.62	4.80	0.16	0.06	S.W.	12	208,200			6.07	+0.3
f	21	572.81	568.00	4.81	0.11	0.19	S.W.	16	214,800			6.22	+0.3
g	22	572.26	567.55	4.71	0.10	0.16	E.	10	203,700			6.01	+0.8
h	22	572.46	567.72	4.74	0.08	0.30	W.	10	208,800			6.13	+1.2
i	22	572.23	567.64	4.60	0.06	0.05	W.	8	202,400			5.95	−0.6
j	25	572.52	567.79	4.73	0.35	0.22	S.W.	10	207,000			6.07	−0.1
k	27	572.57	567.79	4.78	0.05	0.30	S.W.	4	203,100			5.91	−3.2
l	28	572.64	567.81	4.83	0.06	0.17	S.W.	10	200,700			5.86	−4.6
m	28	572.21	567.70	4.51	0.14	0.30	S.W.	16	197,500			5.80	−1.7
n	29	572.70	567.94	4.76	0.07	0.64	S.W.	26	208,900			6.07	−1.4
o	29	572.71	567.94	4.77	0.23	0.18	N.W.	25	207,300			6.02	−2.2
p	29	572.01	568.11	4.90	0.41	0.07	W.	25	214,400			6.18	−2.0
q	29	572.86	568.09	4.77	0.05	0.41	S.W.	25	213,400			6.16	−0.9

Williams Exhibit 24

TABLE No. 2
SUMMARY OF DISCHARGES
Open Section
NIAGARA RIVER

Sheet 1 (5 Sheets)

Levels of 1903
P. B. M. Buffalo Lighthouse 580.101
P. B. M. Guard Lock..... 576.454

F. C. Shenehon, U. S. Asst. Engr.

Reference No. of Measurement	Date		Elevation of Water Surface Above Mean Tide, New York		Fall Lake Erie to Section	Change at Lake During Measurement, Feet		Wind		Discharge Cubic Feet Per Second	Meter and Rating		Weighted Mean Index Velocity	Percentage Error
			Lake Erie Level	Section Gage		Rise	Fall	Direction from which it Blows	Approx. Velocity Miles per Hour		Meter L.S. 4A	Meter L.S. 3B		
	1903													
1	Aug.	30	571.80	566.93	4.87	0.02	0.00			191,000		4	5.13	+1.2
2		31	572.14	567.16	4.98	0.00	0.07			200,200		4	5.33	+1.2
3		31	571.93	567.07	4.86	0.21	0.03			186,800		4	5.25	+1.2
4		31	571.85	567.02	4.83	0.00	0.15			182,000		4	5.19	+1.2
5	Sept.	1	571.87	566.96	4.91	0.21	0.23			188,100		4	5.32	+1.2
6		1	572.22	567.19	5.03	0.12	0.08			203,600		4	5.45	+1.2
7		2	571.77	566.94	4.83	0.23	0.08			189,900		4	5.11	+1.2
8		4	571.89	566.88	5.01	0.06	0.14			190,600		4	5.17	+1.2
9		7	571.70	566.75	4.95	0.26	0.22			184,700		4	4.99	+1.2
10		7	571.73	566.84	4.91	0.24	0.25			184,200		4	4.99	+1.2
11		8	572.02	566.94	5.14	0.33	0.13	S.W.	18	196,600		4	5.25	+0.2
12		14	571.73	566.67	4.96	0.33	0.06	S.W.	20	188,200		4	5.07	+0.2
13		15	571.63	566.74	4.89	0.11	0.06	N.W.	4	186,600		4	5.06	+0.2
14		15	571.70	566.62	4.97	0.13	0.11	S.W.	8	189,460		4	5.11	+0.2
15		15	571.78	566.52	4.92	0.05	0.04	S.W.	4	185,700		4	5.02	+0.2
16		16	571.70	566.57	4.93	0.41	0.01	S.W.	4	185,800		4	5.02	+0.2
17		16	571.65	566.79	4.86	0.60	0.30	S.W.	12	183,500		4	4.96	+0.2
18		16	571.40	566.60	4.80	0.10	0.16	S.W.	8	180,800		4	4.89	+0.2
19		16	571.76	566.88	4.88	0.02	0.08	S.W.	16	185,000		4	5.02	+0.2
20		16	571.87	566.88	4.99	0.28	0.08	S.W.	16	190,200		4	5.13	+0.2
21		18	571.93	566.96	4.96	0.44	0.07	S.W.	20	191,600		4	5.16	+0.2
22		19	571.80	566.67	4.93	0.12	0.12	N.E.	10	183,200		4	5.01	+0.2
23		19	571.53	566.76	4.77	0.08	0.02	N.E.	12	176,000		4	4.84	+0.2
24		19	571.43	566.57	4.86	0.07	0.10	N.E.	12	178,100		4	4.89	+0.2
25		20	571.73	566.76	4.96	0.02	0.21	N.	15	186,000		4	5.07	+0.2
26		20	571.77	566.80	4.97	0.18	0.07	N.	10	185,800		4	5.13	+0.2
27		20	571.69	566.86	4.97	0.11	0.03	N.W.	5	189,400		4	5.04	+0.2
28		21	*571.95	566.95	4.99			N.W.	15	187,300		4	5.07	+0.2
29		21	572.24	567.21	5.12	0.40	0.02	W.N.W.	15	201,000		4	5.36	+0.2
30		22	571.55	566.86	4.70	0.10	0.14	N.W.	28	181,800		4	4.98	+0.2
31		22	572.08	566.98	5.10	0.42	0.00	N.W.	28	198,600		4	5.21	+0.2
32		25	571.50	566.58	4.92	0.52	0.28	S.E.	8	186,500		4	5.08	+1.2
33		25	571.53	566.61	4.92	0.10	0.43	S.E.	8	181,000		4	4.96	+1.2
34	Oct.	4	571.66	566.73	4.93	0.02	0.17	N.	8	186,200	5		4.94	+0.2
35		5	571.39	566.59	4.80	0.11	0.03	N.	4	181,900	5		4.88	+0.2
36		6	571.43	566.51	4.91	0.12	0.10	N.E.	8	181,600	5		4.87	+0.2
37		6	571.44	566.53	4.92	0.10	0.03	N.E.	10	181,400	5		4.86	+0.2
38		7	571.57	566.56	5.01	0.00	0.05	S.E.	4	183,400	5		4.96	+0.2
39		7	571.38	566.47	4.91	0.01	0.42	N.E.	5-13	178,700	5		4.75	+1.2
40		9	571.78	566.76	5.02	0.31	0.14	S.W.	15-8	192,500	5		5.11	+1.2
41		11	571.35	566.51	4.84	0.17	0.22			181,900	5		4.87	+0.2
42		11	571.60	566.59	5.01	0.24	0.00	S.W.	0-8	186,800	5		4.98	+0.2
43		13	571.39	566.43	4.96	0.28	0.20	S.W.	8	180,000	5		4.85	+0.2
44		13	571.33	566.51	4.82	0.06	0.16	S.W.	4	180,200	5		4.83	+0.2
45		15	571.48	566.53	4.95	0.00	0.04	S.W.	6	182,500	5		4.88	+0.2
46		19	571.55	566.57	4.98	0.10	0.22	N.	3-7	182,200	5		4.90	+0.2
47		20	571.20	566.31	4.89	0.05	0.16			177,700	5		4.81	+0.2
48		20	571.43	566.43	4.99	0.32	0.12	N.N.E.	3-10	182,100	5		4.93	+0.2
49		21	571.26	566.25	4.99	0.07	0.07	E.	7	179,600	5		4.86	+0.2
50		21	571.27	566.25	4.99	0.00	0.13	N.E.	5	179,400	5		4.85	+0.2
51		27	571.41	566.51	4.90	0.14	0.28	E.	4	185,000	5		4.96	+0.2
52		27	571.36	566.40	4.96	0.07	0.15	N.E.-E.	10-13	182,500	5		4.93	+0.2
53		28	571.49	566.52	4.97	0.25	0.20	S.W.-S.E.	8-3	185,700	5		4.98	+0.2
54		29	572.02	566.51	5.51	0.69	0.09	S.W.	20-14	199,800	5		5.38	+0.2
55		30	571.63	566.62	5.00	0.22	0.11	N.E.-W	3	180,400	5		5.07	+0.2
56		31	571.57	566.62	4.94	0.04	0.24	N.N.E.	4	185,400	5		4.96	+0.2
57		31	571.53	566.70	4.98	0.22	0.14	E.N.E.	4	180,600	5		4.89	+0.2
58		31	571.12	566.45	4.67	0.06	0.16	N.E.	4	170,400	5		4.63	+0.2
59	Nov.	1	571.01	566.63	4.38	0.38	0.20	N.-N.E.	20-15	163,800	5		4.42	+0.2
60		2	570.78	566.69	4.10	0.15	0.27	N.E.	10	159,400	5		4.33	+0.2
61		2	570.82	566.64	4.18	0.62	0.31	N.E.	8	163,800	5		4.43	+0.2
62		3	571.10	566.12	5.04	0.24	0.37	SE.-NE	10	195,800	5		5.31	+0.2
63		3	570.67	566.93	4.74	0.04	0.59	E.N.E.	7	166,200	5		4.57	+0.2
64		4	572.39	567.33	5.06	0.97	0.25	S.W.	15-13	214,400	5		5.38	+1.2
65		4	572.29	567.31	5.03	0.11	0.39	W.	20	222,000	5		5.38	0.0

*Gage height interpolated from Section Gage.

See Table No. 4.

Williams Ex. 24 — Sheet 5 (5 Sheets)

TABLE No. 2

SUMMARY OF DISCHARGES

Open Section

NIAGARA RIVER

Levels of 1903
P. B. M. Buffalo Lighthouse 580.101
P. B. M. Guard Lock..... 576.454

F. C. Shenehon,
U. S. Asst. Engr.
1906

Discharge No.	Date	Elevation of Water Surface Above Mean Tide, New York: Lake Erie Level	Elevation of Water Surface Above Mean Tide, New York: Section Gage	Fall Lake Erie to Section	Change At Lake During Measurement Feet: Rise	Change At Lake During Measurement Feet: Fall	Wind: Direction from which it Blows	Wind: Approx. Velocity Miles per Hour	Discharge Cubic Feet Per Second	Meter and Rating: Meter L.S. 4A	Meter and Rating: Meter L.S. 2B	Weighted Mean Index Velocity	Percentage Residuals
	1899												
60	Nov. 6	571.84	566.65	4.99	0.00	0.07	N.W.	2	153,400	5		4.94	−0.5
61	7	571.86	566.89	4.97	0.15	0.15	N.W.-W.	1-5	154,200	5		4.92	−0.2
62	11	571.46	566.43	5.03	0.05	0.26	E.N.E.	10	151,700	5		4.98	−0.7
63	11	571.17	566.30	4.87	0.84	0.23			174,400	5		4.73	−1.3
70	22	570.73	566.89	4.84	0.15	0.34	N.E.	8	167,500	5		4.82	0.0
71	23	570.84	566.75	4.79	0.14	0.10	N.E.-E.	8-10	164,300	5		4.80	+0.4
72	24	571.32	566.28	5.03	0.31	0.13	N.E.	1	155,700	5		4.94	+1.7
73	24	571.43	566.38	5.00	0.14	0.05	NE NW	4	153,500	5		4.91	+1.5
74	25	571.43	566.43	5.01	0.08	0.19	N.E.-N	4	153,200	5		4.91	+0.2
75	26	571.30	566.33	4.97	0.15	0.05	N.W.	6	151,900	5		4.92	+1.5
76	27	571.84	566.45	5.11	0.28	0.02	S.W.	2	156,400	5		5.08	+2.0
77	27	571.72	566.89	5.19	0.15	0.04	S.W.-W.	5	191,800	5		5.13	+2.0
78	28	571.97	566.76	5.21	0.22	0.05	S.W.	12	194,500	5		5.15	+0.6
79	28	571.58	566.76	5.12	0.11	0.20	S.W.	15	193,300	5		5.13	+1.0
80	29	571.78	566.61	5.14	0.26	0.02	W.	2	190,300	5		5.08	+0.5
81	29	571.68	566.64	5.04	0.13	0.23	S.W.	10	185,700	5		5.02	+0.9
82	Dec. 2	572.63	567.27	5.36	0.14	0.29	S.W.	30	207,400	5		5.26	−0.1
83	2	572.41	567.07	5.34	1.66	0.06	S.W.	20-30	206,600	5		5.40	+1.9
84	4	571.46	566.36	5.09	0.28	0.06	W-N.W.	3-5	182,100	5		4.96	−0.1
85	4	571.78	566.56	5.17	0.06	0.06	N.W.	0-1	189,000	5		5.06	+0.4
86	5	571.89	566.66	4.90	0.84	0.70	W.N.W.	c	195,200	5		4.81	+3.2
87	6	572.17	567.22	4.95	0.16	0.30	W.N.W.	30	192,800	5		5.01	+1.9
88	6	571.71	566.77	4.94	0.14	0.61	N.W.	10	184,400	5		4.89	+1.8
89	9	570.88	565.96	4.92	0.41	0.26	E.	7	168,500	5		4.88	+1.2
90	9	570.98	565.92	5.00	0.21	0.06	E.	3	169,600	5		4.89	+1.0
	1900												
91	June 26	572.73	567.41	5.32	0.88	0.13	S.W.	10-20	215,900	5	See Table No. 4.	5.40	+2.9
92	26	573.04	567.71	5.33	0.06	0.55	S.W.	34	216,300	5		5.57	+0.9
93	26	572.41	567.31	5.10	1.06	0.05	S.W.	15-40	228,900	5		5.33	+1.8
94	26	572.94	567.91	5.03	0.06	0.96	N.W.	45	214,100	5		5.41	−0.1
95	30	572.80	567.50	5.30	0.61	0.48	NW-W.	12-20	215,300	5		5.53	+0.9
96	30	572.96	567.73	5.22	0.31	0.20	W.-N.W.	30-35	214,100	5		5.46	+0.3
97	July 5	573.33	567.20	5.13	0.06	0.19	S.W.	4-5	201,600	14		5.36	+0.4
98	5	572.41	567.25	5.16	0.18	0.13	S.W.	5-13	202,900	14		5.43	+0.6
99	6	573.76	567.46	5.30	0.13	0.15	S.W.	10-20	208,900	14		5.40	+0.8
100	6	573.66	567.47	5.19	0.04	0.12	S.W.	20	206,600	14		5.43	+0.8
101	9	573.15	567.78	5.37	0.20	0.32	N.W.	5	221,400	14		5.71	+1.1
102	9	573.09	567.43	5.66	0.10	0.35	W.N.W.	5	205,900	14		5.37	+1.4
103	10	573.25	567.19	5.06	0.03	0.35	NW-SW	5-10	200,700	14		5.34	+0.4
104	10	572.77	567.41	5.36	0.42	0.15	S.W.	15	214,300	14		5.64	+1.8
105	11	572.71	567.61	5.10	0.19	0.09	S.	15-25	205,000	14		5.37	+2.1
106	11	572.26	567.24	5.02	0.32	0.28	S.W.	25-30	195,800	14		5.20	+1.8
107	12	573.21	567.72	5.49	0.16	0.60	NW-W.	5-25	216,900	14		5.66	+1.6
108	12	573.04	567.41	5.63	0.06	0.79	W.S.W.	20	213,100	14		5.53	+1.6
109	13	572.26	567.20	5.06	0.06	0.07	W-N.W.	3-5	199,300	14		5.27	+1.4
110	14	572.82	567.25	5.17	0.10	0.04	S.W.	5	203,900	14		5.38	+0.9
111	14	572.26	567.21	5.05	0.03	0.20	W.S.W.	15	194,400	14		5.17	+0.6
112	15	572.33	567.26	5.07	0.24	0.04	S.W.	15	200,700	14		5.23	+0.2
113	16	572.15	567.13	5.02	0.10	0.15	S.W.	15	196,500	14		5.24	+0.3
114	17	572.88	567.38	5.50	0.09	0.05	W.	24-40	215,200	14		5.44	+1.6
115	17	572.36	567.36	5.00	0.10	0.30	S.W.	40	201,600	14		5.23	0.0
116	18	572.26	567.20	5.06	0.27	0.20	NW-SW	10-5	201,300	14		5.23	0.0
117	19	573.11	567.00	5.02	0.39	0.24	S.E.	3	201,100	14		5.36	+2.5
118	20	572.39	567.32	5.07	0.26	0.04	S.W.	10	201,600	14		5.32	0.4
119	21	572.25	567.21	5.04	0.37	0.29	N.W.	10	199,600	14		5.09	0.7
120	22	572.38	567.10	5.28	0.12	0.21	S.W.	0-2	199,600	14		5.29	0.2
121	24	572.22	567.17	5.05	0.28	0.13	S.-S.W.	4-6	200,300	14		5.31	+0.8

Williams Ex. 25

TABLE No. 2
SUMMARY OF DISCHARGES
Three Points Section
ST. LAWRENCE RIVER

Sheet 1 (2 Sheets)
F. C. Shenehon
Assistant Engineer
May, 1921

Reference No. of Measurement	Date	Elevation of Water-Surface Above Mean Tide, N. Y.		Fall Ogdensburg to Section	Change at Ogdensburg during Measurement		Wind		Discharge Cubic Feet per Second	Meter Used			Approximate Weighted-Mean Index Velocity	Percentage Variation
		Ogdensburg at Gage 12	Section Gage		Rise	Fall	Direction from which it Blows	Approx. Velocity in Miles per hour		4 A	2 B	3 B		
1	Sept. 26	244.14	226.50	17.64	0.12	0.02	O.	0	232,800	1			4.78	+1.0
2	27	244.08	226.40	17.68	.06	.06	O.	0	223,000	1			4.80	+0.3
3	27	244.10	226.37	17.73	.05	.03	W.	5	233,300	1			4.81	+0.3
4	28	243.99	226.32	17.67	.00	.07	N.	7	219,700	1			4.85	+0.8
5	28	244.02	226.33	17.69	.01	.02	N.	5	221,100	1			4.78	+0.5
6	Oct. 1	243.94	226.15	17.79	.06	.07	E.	5	219,300	1			4.72	+0.5
7	3	244.04	226.32	17.72	.02	.10	W.	5	219,400	1			4.78	+1.3
8	4	244.13	226.41	17.72	.05	.09	S.W.	10	233,800	1			4.67	+2.3
9	5		226.42				S.W.	11	223,000	1			4.56	
10	9	243.90	226.20	17.91	.20	.03	N.E.	6	217,700	1			4.62	+1.3
11	10	243.80	226.20	17.81	.17	.00	N.	5	216,200	1			4.79	-0.4
12	11	243.94	226.06	17.88	.25	.00	N. W.	2 5	219,400	1			4.78	+0.1
13	12		226.16				S.W.	10	231,100	1			4.81	
14	17	243.84	226.06	17.78	.24	.20	W. S.W.	4-10 15-20	217,000	1			4.73	-0.5
15	18	244.05	226.37	17.68	.00	.30	W.	13	232,800	1			4.79	-0.6
16	19	243.83	226.68	17.15	.15	.22	N.	5	208,400	1			4.56	+1.2
17	22	243.83	226.66	17.17	.11	.08	S.	7	215,000	1			4.68	+0.5
18	23	243.77	226.70	17.07	.15	.06	S.	7	213,300	1			4.63	+0.5
19	24	243.90	226.96	17.93	.06	.06	S.W. N.W.	4	217,700	1			4.75	-0.3
20	25	243.86	226.46	17.40	.00	.00	N.E.	5	208,200	1			4.66	0.0
21	26	243.73	226.51	17.97	.15	.08	S.	6	213,700	1			4.66	+1.0
22	29	243.75	226.72	17.03	.17	.08	S.	1	210,500	1			4.62	+1.5
23	30	243.25	226.20	17.05	.50	.51	N.E.	15	180,200	1			4.34	-0.5
24	31	243.69	226.53	17.16	.33	.00	N.E. S.W.	5 1	209,000	1			4.64	+1.1
25	Nov. 1	243.90	226.00	17.37	.06	.13	S.	11	215,800	1			4.69	+1.0
26	2	244.07	226.63	17.44	.20	.16	S.W. W.	17 8	222,700	1			4.80	-0.3
27	2		226.66				N.W.	1	211,700	1			4.66	
28	8	243.65	226.64	17.01	.13	.06	N.E.	5	212,500	1			4.63	-0.7
29	10	244.04	226.34	17.70	.00	.17	S.W. W.	12 9	221,700	1			4.77	+0.3
30	12	243.81	226.23	17.58	.05	.14	S. S.W.	10 8	216,700	1			4.74	-0.5
31	14	243.89	226.61	17.28	.19	.31	N.W. S.W.	3 3	215,300	1			4.74	-0.7
32	25	244.13	226.47	17.66	.13	.20	W.	9	224,600	1			4.82	+0.1
33	27	243.40	226.16	17.24	.11	.07	N.W.	4	207,400	1			4.64	-1.0
34	28	243.49	226.48	17.01	.00	.07	N.E.	6	207,800	1			4.61	-0.6
35	30	243.51	226.23	17.28	.05	.03	N.E.	1	212,500	1			4.77	-1.4
36	Dec. 4	243.70	226.72	17.98	.00	.13	N.E.	9	215,400	1			4.74	-1.3
37	5	243.60	226.70	17.16	.13	.04	N.E.	7	215,200	1			4.74	0.0
38	6	244.02	226.10	17.84	.04	.10	N.W.	3	223,000	1			4.83	-0.5
39	7	244.19	226.40	17.79	.20	.10	S.W. N.	5 4	227,700	1			4.90	-0.4
	1921													
40	Apr. 20	244.28	227.24	17.85	.04	.04	E. S.W.	2	248,200	1			5.27	+0.1
41	20	244.23	227.24	17.27	.01	.04	S.W.	1	250,800	1			5.22	-0.2
42	20	244.20	227.24	17.42	.05	.08	E.	2	246,900	1			5.14	+0.4
43	30	244.01	227.2	17.26	.01	.08	E.	2	246,000	1			5.15	-0.0
44	May 2	244.47	227.37	17.80	.04	.18	N.W. N.W.	18 20	245,400	1			5.10	+0.6
45	2	244.23	227.43	17.46	.09	.09	N.W. N.W.	18 20	243,100	1			5.11	+1.3
46	3	244.38	227.24	17.66	.14	.02	E. W.	1	243,400	1			5.07	+0.9
47	6	244.26	227.43	17.46	.07	.03	W.	1	249,300	1			5.18	-0.2
48	9	244.23	227.46	17.45	.03	.01	N. S.W.	1	249,000	1			5.16	-0.1
49	7	244.24	227.50	17.26	.09	.01	S.	1	248,900			1	5.17	+0.1
50	7	244.27	227.51	17.26	.01	.03	S.	1	252,100			1	5.23	-0.9
51	7	243.96	227.54	17.42	.08	.03	S.	1	251,700			1	5.22	+0.1
52	8	244.20	227.41	17.29	.03	.04	S.	1	244,500	1			5.07	+0.1
53	8	244.20	227.42	17.42	.11	.00	S.	1	243,900	1			5.04	+1.5
54	8	244.22	227.40	17.44	.02	.04	S.	1	242,100	1			5.05	+0.8
55	8	244.20	227.39	17.41	.02	.02	S.	1	248,200	1			5.15	-1.4
56	8	244.18	227.37	17.81	.02	.04	E.	2-1	248,600	1			5.15	-1.3
57	9	244.26	227.41	17.44	.06	.02	E.	2-1	246,700	1			5.15	-0.3
58	10	244.05	227.39	17.37	.07	.03	E.	2-1	243,400	1			5.04	-0.3
59	10	244.17	227.33	17.46	.00	.02	E.	2-1	245,600	1			5.10	-0.5
60	10	244.24	227.41	17.48	.14	.02	N. S.E.	1 10	248,700	1			5.13	-0.3
61	14	245.00	227.76	17.21	.00	.03	S.W. S.	10 4	252,700	1			5.16	+0.6
62	14	245.01	227.64	17.32	.02	.04	S.W. S.	8 3	251,900	1			5.18	-0.4
63	14	245.00	227.67	17.28	.01	.04	S.W. S.	10 4	247,200	1			5.07	+1.0

Williams Ex. 25

TABLE No. 3.
SUMMARY OF DISCHARGES
Three Points Section
ST. LAWRENCE RIVER

Sheet 2
(2 Sheets)
F. C. Shenehon,
Assistant Engineer.
May, 1906

Measurement No.	Date	Elevation of Water Surface Above Mean Tide, N. Y.		Fall Ogdensburg Section 2	Change at Ogdensburg during Measurement		Wind		Discharge Cubic Feet per Second	Meter Used			Approximate Weighted-Mean Index Velocity	Percentage Residuals
		Ogdensburg at Gage 12	Section Gage		Rise	Fall	Direction from which it Blows	Approx. Velocity in Miles per hour		4 A	2 B	3 B		
64	May 15	244.97	237.61	17.36	0.06	0.01	S.	2-13	249,400		1		5.06	+0.2
65	15	245.00	237.66	17.34	.01	.00	S.	7-8	251,100		1		5.10	−0.1
66	15	244.99	237.68	17.31	.01	.01	S.	2-12	251,700	1			5.13	−0.5
67	16	244.93	237.54	17.39	.13	.00	S.	2	248,500	1			5.14	−0.1
68	16	244.97	237.40	17.57	.01	.06	S.	5	250,400	1			5.12	−0.3
69	16	244.93	237.60	17.33	.04	.03	S.W.	10	251,200	1			5.20	−1.0
70	June 18	244.88	237.43	17.45	.17	.01	N.	3	250,000	1			5.23	−1.1
71	18	244.94	237.56	17.38	.06	.01	E.	1	248,700	1			5.13	+0.2
72	18	244.93	237.56	17.37	.02	.17	S. E.	2-5 1	248,900	1			5.11	−0.1
73	19	244.84	237.50	17.34	.00	.05	S.	1	248,800	1			5.17	−1.1
74	19	244.95	237.56	17.37	.04	.05	W. S.	20 2	250,600	1			5.19	−0.6
75	19	245.00	237.72	17.37	.16	.22	E.	8-10	249,700	1			5.15	+1.6
76	20	244.94	237.42	17.36	.02	.02	S.	1	246,000	1			5.09	+0.1
77	20	244.87	237.51	17.28	.37	.20	S.	1	248,900	1			5.14	−0.6
78	20	245.09	237.64	17.45	.19	.18	S.	1	246,100	1			5.04	+3.0
79	21	244.91	237.61	17.30	.14	.06	S.W.	10	250,500	1			5.16	−1.0
80	21	245.01	237.68	17.33	.04	.03	S.W.	12	249,900	1			5.13	−0.4
81	21	245.06	237.74	17.34	.09	.09	S.W.	10	252,800	1			5.20	−0.2
82	22	244.93	237.49	17.33	.06	.06	N.W.	1	246,800	1			5.10	−0.6
83	23	244.90	237.50	17.40	.04	.00	W.	1	251,100		1		5.19	−1.3
84	24	245.05	237.74	17.31	.00	.04	N.W.	1-3	251,400	1			5.15	+0.3
85	24	245.05	237.72	17.33	.00	.00	S.	2	251,500	1			5.17	−0.2
86	24	245.13	237.77	17.36	.09	.01	W.	2-5	252,700	1			5.19	+0.7
87	25	244.99	237.71	17.28	.13	.01	S.W.	2	252,400	1			5.20	−0.8
88	25	245.06	237.71	17.35	.06	.13	S.W.	3	253,100	1			5.21	−0.3
89	25	245.23	237.67	17.56	.18	.00	S.W.	5	252,600	1			5.30	−1.9
90	26	244.94	237.61	17.33	.03	.03	W.	2	250,700	1			5.19	+0.7
91	26	245.02	237.63	17.39	.08	.00	W.	1	250,200	1			5.18	+0.4
92	26	244.97	237.63	17.34	.03	.03	W.	2-5	249,300	1			5.13	+0.2
93	July 2	245.17	237.90	17.27	.13	.07	S.W.	18-15	249,200	1			5.12	−2.6
94	2	245.25	237.90	17.35	.04	.04	S.W.	18-15	250,900	1			5.14	−3.8
95	3	245.01	237.62	17.39	.05	.09	N.E.	2	250,700			1	5.10	−0.1
96	3	244.94	237.56	17.38	.02	.02	N.	2	248,700			1	5.08	+0.2

WILLIAMS EX. 26. Sheet 1

TABLE No. 1. LAKE SUPERIOR AT SUPERIOR, WIS., AND MARQUETTE, MICH.

Monthly means of water levels above mean tide at New York. Marquette readings depend on zero of gage-601.75 and B. M. 3-609.91 sea level elevations. U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860 a	c602.44	c602.19	c602.19	602.69	602.92	603.09	603.05	603.10	603.08	603.12	602.95	c602.59	602.78
1861 a	c602.48	602.15	602.01	602.42	603.05	603.20	603.36	603.32	603.23	603.26	602.92	602.54	602.83
1862 a	602.19	602.00	602.03	602.09	602.77	602.76	602.73	602.90	603.02	602.95	602.62	602.35	602.53
1863 a	602.16	602.03	601.86	601.90	602.03	601.95	602.09	602.71	602.73	602.56	602.21	602.10	602.19
1864 a	601.81	601.60	601.67	601.69	601.85	602.00	602.09	602.10	602.25	601.99	601.80	601.65	601.87
1865 a	601.47	601.46	601.33	601.77	602.26	602.67	602.99	603.07	603.08	602.87	602.34	602.03	602.28
1866 a	601.74	601.53	601.53	601.98	602.23	602.42	602.71	602.94	602.67	602.69	602.36	602.47	602.27
1867 a	602.20	602.09	601.90	602.12	602.12	602.72	603.05	602.93	603.01	602.90	602.56	602.24	602.49
1868 a	602.08	601.49	601.85	602.04	602.44	602.35	602.57	602.49	602.62	602.50	602.75	602.32	602.30
1869 a	602.10	601.86	601.41	601.99	602.39	602.40	602.77	603.23	604.08	603.56	603.22	602.57	602.63
1870 a	602.32	602.11	602.12	602.22	602.55	602.38	602.55	602.55	602.72	602.56	602.38	601.45	602.32
1871 a	601.36	600.76	601.18	601.68	602.21	602.33	602.40	602.46	602.56	602.49	602.42	601.68	601.96
1872 b	601.47	601.36	601.24	601.14	601.79	602.17	602.44	602.61	602.77	602.67	602.52	602.22	602.03
1873 b	602.12	d601.67	d601.70	d601.71	602.31	602.61	602.90	603.08	603.14	603.04	602.90	602.60	602.48
1874 b	d602.15	602.13	602.09	602.19	602.26	602.46	602.84	602.93	603.03	603.09	602.91	602.60	602.56
1875 b	602.28	602.24	602.28	602.28	602.50	602.86	602.85	602.94	603.17	603.02	602.88	602.68	602.67
1876 b	602.48	602.27	602.18	602.21	602.75	603.43	603.82	603.93	603.82	603.49	603.33	603.05	603.06
1877 b	602.69	602.45	602.19	602.11	602.10	602.32	602.70	602.76	602.60	602.60	602.39	602.32	602.44
1878 b	602.20	602.32	601.55	601.52	601.79	602.07	602.14	602.02	601.85	601.92	601.72	601.40	601.87
1879 b	d601.50	601.46	601.76	601.37	601.01	601.24	601.48	601.60	601.49	601.58	601.50	d601.20	601.43
1880 b	d600.88	d600.84	d600.75	d600.78	d601.47	602.30	602.45	602.44	602.44	602.30	602.33	602.07	601.76
1881 b	601.81	601.71	601.62	601.53	601.83	602.27	602.33	602.38	602.61	602.95	602.88	602.60	602.21
1882 b	602.25	602.00	601.89	601.81	601.97	601.99	602.44	602.56	602.60	602.43	602.41	602.22	602.21
1883 b	601.99	601.70	601.70	601.95	601.98	602.06	602.31	602.33	602.29	602.09	601.94	601.83	602.01
1884 b	d601.76	d601.73	d601.61	601.32	601.54	601.74	601.88	601.89	602.16	602.52	602.42	602.21	601.90
1885 b	601.98	601.80	601.72	601.67	602.00	602.28	602.52	602.64	602.57	602.40	602.25	601.92	602.15
1886 b	601.72	601.59	601.53	601.62	601.87	602.01	602.08	601.99	601.97	602.07	601.92	601.78	601.85
1887 b	601.47	601.49	601.80	601.97	601.76	601.92	602.20	602.28	602.14	602.07	601.83	601.61	601.88
1888 b	601.50	601.51	601.44	601.44	601.91	602.09	602.38	603.02	602.97	602.88	602.74	602.39	602.28

1889 b	602.07	601.85	601.68	601.69	603.04	602.16	602.35	602.54	602.67	602.51	602.20	601.90	602.14
1890 b	601.76	601.63	601.39	601.36	601.57	602.02	602.32	602.47	602.60	602.57	602.36	602.00	602.00
1891 b	601.64	601.51	601.47	601.43	601.69	601.68	601.88	601.95	601.89	601.94	601.83	601.42	601.69
1892 b	601.42	601.14	601.01	601.02	601.35	601.73	601.76	601.88	601.93	601.83	601.66	601.38	601.51
1893 b	601.10	601.01	601.06	601.16	601.66	602.18	602.48	602.54	602.45	602.42	602.26	602.03	601.86
1894 b	601.85	601.67	601.76	601.91	602.69	602.91	602.97	603.10	603.02	603.04	602.99	602.80	602.56
1895 b	602.60	602.28	602.11	602.01	602.38	602.70	602.90	602.95	603.09	603.14	602.85	602.52	602.62
1896 b	602.32	602.12	601.92	602.01	602.66	603.04	603.10	603.12	602.95	602.63	602.70	602.55	602.59
1897 b	602.39	602.16	602.08	602.11	602.45	602.78	603.08	603.20	603.14	602.94	602.64	602.21	602.60
1898 b	601.83	601.65	601.46	601.46	601.70	602.18	602.59	602.72	602.82	602.76	602.56	602.33	602.17
1899 b	601.96	601.76	601.79	601.76	602.47	602.96	603.19	603.35	603.51	603.32	603.21	603.00	602.69
1900 b	602.63	602.45	602.23	602.13	602.30	602.36	602.58	602.94	603.46	603.54	603.51	603.13	602.77
1901 b	602.78	602.48	602.28	602.22	602.51	602.61	603.09	603.22	603.04	603.07	603.00	602.68	602.75
1902 b	602.32	602.11	601.97	602.02	602.34	602.64	602.88	602.89	602.93	602.81	e602.81	e602.58	602.53
1903 be	602.24	601.96	601.88	602.07	602.56	602.94	603.14	603.25	603.27	603.40	603.18	602.80	602.73
1904 be	602.50	602.34	602.23	602.17	602.47	602.77	602.86	602.95	603.08	603.26	603.14	602.74	602.71
1905 be	602.47	602.13	602.04	602.26	602.49	602.67	602.97	603.10	603.32	603.33	603.17	602.96	602.74
1906 be	602.72	602.43	602.22	602.15	602.48	602.78	602.90	602.93	602.95	602.84	602.66	602.45	602.63
1907 be	602.22	602.06	601.94	601.94	602.10	602.55	602.70	602.93	603.17	603.15	602.88	602.53	602.51
1908 be	602.10	601.87	601.72	601.63	602.03	602.57	602.85	602.92	602.77	602.59	602.23	601.99	602.27
1909 be	601.69	601.46	601.35	601.29	601.62	601.94	602.18	602.40	602.40	602.29	602.26	602.26	601.93
1910 be	602.01	601.74	601.51	601.62	601.75	601.90	601.88	601.97	601.96	601.92	601.68	601.41	601.78
1911 be	601.07	600.89	600.66	600.54	600.82	601.27	601.62	602.09	602.18	602.18	602.03	601.90	601.44
1912 be	601.76	601.53	601.43	601.45	601.90	602.20	602.35	602.53	602.65	602.60	602.44	602.20	602.09
1913 be	601.89	601.57	601.51	601.64	602.07	602.36	602.64	602.78	602.83	603.02	602.88	602.70	602.32

a Superior, Wis. b Marquette, Mich. c Interpolated by the same differences to the observed monthly means for that year as are found in the means of monthly means for the ten year series 1862-71. d Interpolated by applying the average difference of Marquette, Mich., and Sault Ste. Marie, Mich., water levels for the year to the monthly mean at Sault Ste. Marie Mich. e From records of self-registering gage.

Note.—Superior, Wis., records are found in Report of Chief of Engineers 1876, and are reduced to sea level elevations and 0.45 ft. added to reduce to the new levels. This difference of 0.45 ft. is the same as used to correct the levels at Duluth, Minn. There is an uncertainty of 0.4 ft. in the elevation of the zero of the gage at Superior, Wis. The possible alternative would make the levels 0.4 ft. lower than given in the table. The Marquette, Mich., records are considered reliable.

TABLE No. 2. LAKE MICHIGAN AT MILWAUKEE, WIS.

Monthly means of water levels above mean tide at New York, depending on check point. (1876) on Chestnut St. Bridge (destroyed) as 586.55, and check point (1902) on same bridge as 584.47 Sea level elevations in ft. U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	582.51	582.60	582.72	582.85	582.97	583.09	583.13	582.94	582.74	582.43	582.10	581.94	582.68
1861	581.83	581.92	582.31	582.41	582.83	582.99	583.12	583.36	583.05	582.93	582.70	582.53	582.66
1862	582.33	582.18	582.48	582.64	582.89	583.02	582.92	582.91	582.84	582.73	582.34	582.20	582.62
1863	582.13	582.18	582.17	582.17	582.38	582.47	582.42	582.20	582.11	582.02	581.58	581.92	582.15
1864	581.69	581.55	581.80	581.51	582.02	582.01	581.91	581.73	581.46	581.07	580.90	580.77	581.53
1865	580.56	580.65	580.82	581.31	581.47	581.51	581.94	581.96	581.84	581.60	581.04	580.73	581.29
1866	580.47	580.23	580.28	580.73	580.91	581.20	581.46	581.52	581.37	581.26	581.17	580.91	580.96
1867	580.89	580.94	581.12	581.41	581.63	581.94	582.00	582.02	581.75	581.42	580.96	580.61	581.40
1868	580.45	580.41	581.09	580.99	581.27	581.48	581.51	581.17	580.93	580.70	580.63	580.35	580.91
1869	580.25	580.32	580.06	580.43	580.76	581.20	581.67	581.93	581.82	581.46	581.34	581.06	581.03
1870	581.12	581.21	581.51	581.93	582.27	582.41	582.52	582.43	582.57	582.17	581.77	581.42	581.94
1871	581.57	581.49	582.09	582.29	582.64	582.68	582.71	582.48	581.81	581.12	581.07	580.48	581.87
1872	580.35	580.35	580.13	580.38	580.63	581.00	581.03	581.01	580.94	580.82	580.53	579.87	580.59
1873	579.87	579.91	580.22	580.79	581.35	581.96	581.94	582.04	581.85	581.79	581.56	581.52	581.24
1874	581.48	581.77	581.92	581.82	581.80	582.17	582.10	582.11	581.86	581.51	581.31	580.97	581.73
1875	580.77	580.70	580.76	581.12	581.66	581.92	581.89	582.06	581.99	581.84	581.63	581.44	581.48
1876	581.39	581.50	581.92	582.12	582.74	583.15	583.49	583.42	583.37	582.79	582.89	582.42	582.61
1877	582.28	582.29	582.29	582.67	582.56	582.63	582.60	582.48	582.27	582.28	582.16	582.10	582.38
1878	581.96	581.91	582.07	582.09	582.39	582.53	582.54	582.22	582.02	581.91	581.78	581.46	582.07
1879	581.15	581.16	581.20	581.19	581.32	581.39	581.48	581.29	581.17	580.95	580.73	580.76	581.15
1880	580.80	580.71	580.75	580.92	581.26	581.77	581.99	582.02	581.72	581.38	581.06	580.89	581.27
1881	580.90	581.11	581.40	581.31	581.82	582.05	582.02	582.02	581.79	582.12	581.95	581.85	581.70
1882	581.68	581.62	581.99	582.12	582.22	582.49	582.62	582.81	582.69	582.28	582.07	581.74	582.19
1883	581.48	581.52	581.61	581.82	582.30	582.66	583.26	583.23	583.04	582.82	582.37	582.29	582.37
1884	582.07	582.19	582.44	582.62	582.83	582.99	582.83	582.69	582.44	582.44	582.08	582.05	582.47
1885	582.06	582.29	582.25	582.44	582.80	583.01	583.10	583.31	583.17	583.03	582.73	582.44	582.72
1886	582.67	582.69	582.97	583.24	583.50	583.57	583.38	583.15	582.91	582.81	582.47	582.14	582.96
1887	582.06	582.43	582.50	582.54	582.74	582.87	582.81	582.67	582.33	581.88	581.55	581.43	582.32
1888	581.25	581.20	581.38	581.59	581.97	582.24	582.25	582.13	581.98	581.73	581.68	581.10	581.71
1889	581.08	581.05	581.03	581.04	581.12	581.58	581.76	581.52	581.35	581.10	580.75	580.57	581.16
1890	580.65	580.61	580.59	580.91	581.14	581.55	581.62	581.54	581.24	581.23	580.89	580.54	581.05
1891	580.53	580.26	580.47	580.78	580.86	581.03	580.96	580.79	580.56	580.20	579.80	579.74	580.49

1893	579.96	580.08	579.95	580.01	580.42	580.46	580.89	580.97	580.77	580.58	580.20	579.99	580.35
1893	579.96	580.12	580.23	580.69	580.99	581.32	581.34	581.17	580.85	580.71	580.32	580.25	580.67
1894	580.26	580.29	580.55	580.70	581.24	58 40	581.43	581.35	580.92	580.71	580.44	580.09	580.78
1895	579.91	579.80	579.77	579.97	580.13	580.18	580.07	579.95	579.68	579.31	579.09	578.98	579.74
1896	579.06	579.10	579.11	579.29	579.57	579.89	579.83	579.76	579.66	579.61	579.39	579.34	579.47
1897	579.33	579.41	579.72	579.89	580.38	580.65	580.84	580.78	580.53	580.24	579.98	579.76	580.13
1898	579.72	579.86	580.18	580.50	580.78	580.91	580.89	580.69	580.34	580.33	579.92	579.58	580.31
1899	579.53	579.61	579.81	580.08	580.52	580.83	581.04	580.96	580.82	580.49	580.31	579.81	580.32
1900	579.66	579.77	579.94	580.07	580.31	580.42	580.53	580.70	580.65	580.66	580.52	580.19	580.28
1901	579.95	579.92	580.34	580.49	580.92	580.97	581.06	581.11	580.92	580.56	580.23	579.95	580.53
1902	579.76	579.61	579.84	579.91	580.30	580.50	580.83	580.85	580.48	580.33	580.22	579.93	580.21
1903	579.72	579.90	580.09	580.36	580.45	580.63	580.81	580.71	580.79	a580.62	a580.26	a579.94	580.36
1904	a579.99	a579.98	a580.26	a580.72	a581.09	a581.47	a581.48	a581.38	a581.31	a581.18	a580.88	a580.54	580.86
1905	a580.39	a580.31	a580.45	a580.33	a581.09	a581.48	a581.62	a581.59	a581.49	a581.05	a580.78	a580.63	580.98
1906a	a580.61	a580.76	a580.91	a581.09	581.35	581.47	581.48	581.45	581.10	580.91	580.75	580.70	581.05
1907a	580.64	580.68	580.74	581.00	581.16	581.52	581.52	581.44	581.42	581.17	580.76	580.65	581.06
1908a	580.48	580.57	580.64	580.94	581.50	581.64	581.83	581.72	581.28	580.92	580.27	580.13	580.99
1909a	579.88	580.02	580.10	580.36	580.88	581.08	581.05	581.07	580.80	580.32	580.21	580.17	580.50
1910a	579.95	579.94	580.01	580.37	580.50	580.57	580.49	580.33	580.29	580.10	579.78	579.46	580.15
1911a	579.20	579.40	579.23	579.50	579.77	580.05	579.89	579.85	579.75	579.65	579.37	579.48	579.60
1912a	579.27	579.29	579.35	579.52	580.05	580.46	580.53	580.63	580.71	580.41	580.42	580.18	580.07
1913a	580.01	579.84	580.13	580.82	581.13	581.26	581.26	581.26	580.98	580.75	580.44	580.30	580.68
1914a	580.07	580.04											

a From records of self-registering gage on harbor pier.

Note.—These water levels also depend on B. M. on N. E. corner of Dr. Lapham's house at No. 321 Poplar St. as 596.385 ft. The Milwaukee staff gage readings as reduced from publication in previous reports are slightly inconsistent owing to various assumptions in regard to the stability of the gage and reference bench marks. The results of spirit leveling at infrequent intervals show a slight difference in the relative elevations of the reference B. M. on Dr. Lapham's house and the check point on the masonry pier of the Chestnut St. Bridge. In the above table these different results are ascribed to the natural discrepancies of the levels and reductions are made on the assumption that these marks have remained stable and at the relative elevations as originally determined. This assumption is supported by the results of the latest levels (1901). Levels in August, 1901, and November, 1902, indicate that the gage zero had raised 0.03 and 0.05 ft. respectively since the previous test in 1896, explained no doubt by extensive improvements being made in the vicinity. The corrections due to this change in zero have been uniformly distributed. Previous to 1896 the gage zero remained stable with reference to the check point.

The Milwaukee gage is situated at the foot of Poplar St. in the Milwaukee River, about two miles above the mouth and the readings do not indicate the stage of Lake Michigan during high stages of water or ice gorges in the river.

WILLIAMS EXHIBIT 26 Sheet 3.

TABLE No. 3. LAKE HURON AT HARBOR BEACH, MICH.

Monthly means of water levels above mean tide at New York depending on B. M. "Jenks" 610.86 and gage bolt "E" 583.21 sea level elevation in feet U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1874	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1875	581.16	581.10	581.14	581.33	581.68	581.99	582.18	582.15	582.11	581.84	581.20	581.45	.....
1876	581.74	581.72	581.85	582.13	582.73	583.22	583.66	583.60	583.49	583.09	582.94	582.75	582.74
1877	582.46	582.45	582.38	582.46	582.63	582.59	582.77	582.67	582.40	582.26	582.21	582.16	582.45
1878	582.06	581.89	582.06	581.99	582.39	582.56	582.60	582.50	582.21	582.22	582.03	581.83	582.20
1879	581.53	581.29	581.25	581.28	581.41	581.55	581.59	581.46	581.38	581.14	581.02	581.00	581.32
1880	581.06	580.99	580.98	580.99	581.30	581.88	582.19	582.08	581.97	581.61	581.49	581.29	581.49
1881	581.16	581.55	581.56	581.58	581.90	582.07	582.22	582.05	581.89	582.14	582.27	582.10	581.87
1882	581.95	581.72	581.86	582.08	582.25	582.48	582.62	582.48	582.56	582.33	582.08	581.93	582.21
1883	581.73	581.68	581.72	581.73	582.30	582.72	583.20	583.40	583.08	582.75	582.86	582.75	582.49
1884	582.56	582.41	582.45	582.76	582.98	583.04	583.12	583.00	582.65	582.81	582.46	582.20	582.70
1885	582.47	582.38	582.38	582.49	582.89	583.18	583.24	583.39	583.29	583.06	582.87	582.67	582.86
1886	582.67	582.74	582.93	583.22	583.55	583.64	583.48	583.33	583.15	583.02	582.75	582.43	583.06
1887	582.26	582.45	582.66	582.57	582.77	582.89	582.97	582.76	582.41	582.19	581.74	581.45	582.43
1888	581.34	581.25	581.42	581.58	582.00	582.30	582.33	582.37	582.09	581.78	581.60	581.39	581.79
1889	581.25	281.17	581.15	581.08	581.22	581.58	581.61	581.75	581.58	581.21	580.87	580.71	581.28
1890	580.78	580.66	580.64	580.78	581.09	581.52	581.71	581.71	581.44	581.23	581.03	580.73	581.11
1891	580.53	580.42	580.30	580.72	580.96	580.91	580.94	580.84	580.65	580.28	579.97	579.91	580.64
1892	579.93	579.87	579.93	580.05	580.14	580.67	580.99	581.04	580.87	580.66	580.33	580.09	580.38
1893	579.84	579.79	579.87	580.25	580.88	581.21	581.35	581.21	580.91	580.73	580.47	580.28	580.57
1894	580.23	580.24	580.39	580.62	581.02	581.32	581.47	581.20	581.01	580.77	580.58	580.28	580.76
1895	579.96	579.84	579.85	579.95	580.12	580.19	580.16	580.07	579.94	579.65	579.26	579.02	579.83
1896	579.09	579.21	579.11	579.14	579.54	579.91	579.97	580.01	579.83	579.63	579.49	579.38	579.53
1897	579.45	579.36	579.47	579.84	580.41	580.65	580.83	580.84	580.58	580.23	580.07	579.81	580.13
1898	579.66	579.72	579.95	580.44	580.56	580.72	580.82	580.71	580.52	580.21	580.13	579.94	580.28
1899	579.68	579.54	579.69	579.86	580.40	580.79	581.06	580.99	580.79	580.38	580.24	580.05	580.29
1900	579.82	579.83	579.86	579.98	580.13	580.30	580.55	580.64	580.72	580.66	580.66	580.46	580.30

1901	580.22	580.08	580.07	a580.55	580.81	580.91	581.06	581.11	580.93	580.66	580.43	580.10	580.57
1902	580.00	579.81	579.73	579.91	580.16	580.48	580.76	580.83	580.51	580.27	580.17	579.93	580.21
1903	579.74	579.78	579.92	580.27	580.39	580.56	580.75	580.73	580.80	580.83	580.41	580.12	580.36
1904	579.91	579.91	580.08	580.63	580.96	581.42	581.55	581.53	581.36	591.26	580.95	580.50	580.84
1905	580.38	580.30	580.29	580.66	580.95	581.40	581.57	581.56	581.45	581.22	580.93	580.67	580.95
1906	580.53	580.69	580.76	580.94	581.20	581.33	581.45	581.36	581.12	580.87	580.68	580.65	580.95
1907	580.65	580.68	580.68	580.90	581.08	581.30	581.64	581.49	581.42	581.21	580.83	580.62	581.05
1908	580.52	580.43	580.58	580.85	581.26	581.60	581.76	581.67	581.27	580.86	580.46	580.23	580.96
1909	579.90	579.92	580.03	580.14	580.76	581.07	581.13	581.02	580.80	580.40	580.12	580.08	580.45
1910	579.99	579.98	579.99	580.10	580.40	580.54	580.42	580.33	580.20	580.08	579.83	579.52	580.12
1911	579.38	579.35	579.35	579.37	579.66	579.98	579.93	579.85	579.58	579.56	579.44	579.39	579.57
1912	579.35	579.23	579.22	579.44	579.89	580.45	580.41	580.54	580.67	580.54	580.43	580.28	580.04
1913	580.13	580.06	580.08	580.73	580.99	581.14	581.29	581.18	580.88	580.70	580.50	580.38	580.67

a From records of automatic gage after April, 1901.

Note—By Lake Survey levels run in March, 1901, it was found that water levels as being reported from this station were 0.07 ft. too high from the adopted elevations of the reference bench marks. This error was first dropped from the published mean of May, 1901.

The original gage established by Asst. Engr. Gilbert and used until 1884 was probably correct, this error being introduced by the frequent transfer to new gages subsequently set by the gage observers.

This table to Jan., 1892, is reduced from Chief of Engineers reports; from Jan., 1892, to date from records in this office. A correction of 0.07 ft. has been made to the reported monthly mean after Jan. 1, 1895.

There is a lack of data to show definitely when this error was first introduced, the above date being selected arbitrarily, suggested by a comparison with Milwaukee records.

TABLE No. 4. LAKE ST. CLAIR AT ST. CLAIR FLATS CANAL.

Monthly means of water level above mean tide at New York depending on gage zero 575.42 and P. B. M. Old Club 576.571 Sea level elevation in feet. U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1872	.....	.....	.....	.....	.....	.....	575.53	575.67	575.53	575.51	575.02	574.98	.....
1873	574.48	574.71	575.05	575.93	575.95	576.22	576.36	576.35	576.12	575.87	575.68	575.89	575.72
1874	575.11	574.47	575.90	576.12	576.08	576.29	576.46	576.37	576.16	575.92	575.63	575.32	575.82
1875	575.16	575.10	575.26	575.27	575.84	576.01	576.24	576.17	576.02	575.85	575.67	575.57	575.68
1876	575.72	576.17	576.95	576.92	576.69	577.58	577.74	577.57	577.10	576.77	576.66	577.51	576.95
1877	577.04	575.58	574.30	575.26	575.51	576.34	576.59	576.50	576.25	.....	576.30	576.09	.....
1878	575.98	575.06	575.82	.....	.....	576.74	576.86	576.77	576.43	576.24	575.91	575.67	.....
1879	575.26	574.57	575.26	575.81	575.69	.....	.....	.....	.....	.....	.....	.....	.....
1880	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1881	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1882	.....	.....	.....	.....	577.05	.....	577.47	577.46	576.13	575.93	.....	.....	.....
1883	.....	.....	.....	.....	576.40	577.13	577.80	577.72	577.26	576.89	576.23	.....	.....
1884	574.99	575.44	576.81	577.05	577.22	577.39	577.44	577.15	576.79	576.57	576.45	576.42	.....
1885	576.88	576.08	576.92	576.94	576.79	577.16	577.06	577.18	577.03	576.71	576.20	576.38	576.62
1886	575.81	574.92	575.70	576.36	577.05	577.10	577.11	576.99	576.84	576.66	576.67	576.65	576.84
1887	576.30	576.41	576.41	576.61	576.83	576.92	576.92	576.74	576.46	576.13	576.34	576.61	576.46
1888	575.72	575.51	575.22	575.87	575.89	576.10	576.39	576.29	576.05	575.77	575.71	575.67	576.43
1889	575.77	574.83	574.74	575.04	575.42	575.97	576.11	575.96	575.76	575.37	575.64	575.53	575.83
1890	575.50	575.35	575.32	575.71	575.97	576.40	576.33	576.09	575.85	575.63	575.09	575.02	575.42
1891	575.08	575.13	574.92	575.20	575.24	575.35	575.42	575.31	575.18	574.86	575.60	575.45	575.77
1892	574.32	573.57	573.76	574.59	575.13	575.75	575.95	575.77	575.66	575.21	574.62	574.70	575.09
1893	573.76	573.86	574.70	575.13	575.54	575.88	575.92	575.74	575.48	575.22	574.82	574.60	574.93
1894	575.05	574.55	574.92	575.07	575.52	575.75	575.79	575.60	575.44	575.18	574.94	575.04	575.10
1895	575.34	575.35	574.75	574.25	574.55	574.69	574.75	574.71	574.50	574.19	574.94	574.86	575.22
1896	574.23	573.39	573.62	574.15	574.40	574.76	574.93	575.00	574.77	574.67	574.21	574.19	574.60
1897	574.48	574.83	574.78	574.82	575.24	575.34	575.49	575.46	575.20	574.84	574.67	574.70	574.99

1898	574.64	574.16	574.79	575.23	575.33	575.55	575.60	575.46	575.19	574.93	574.88	574.96	575.06	
1899	574.86	574.63	574.59	574.71	575.13	575.40	575.57	575.51	575.20	574.90	574.77	574.71	575.00	
1900	574.24	574.35	574.83	574.93	575.04	575.21	575.29	575.34	575.22	575.07	574.94	574.80	574.94	
1901	574.65	573.74	574.02	573.23	574.33	575.09	575.30	575.30	575.28	574.96	574.67	574.70	574.61	
1902	.....	.....	.....	574.52	574.76	575.13	575.76	575.62	575.34	575.24	574.95	575.06	.....	
1903	575.25	.....	.....	.....	575.42	575.55	575.68	575.60	575.39	575.45	574.95	575.35	.....	
1904	574.18	574.50	a575.64	575.91	575.86	576.19	576.25	576.14	575.98	575.74	575.34	575.45	575.60	
1905	574.52	574.20	574.81	575.11	575.45	575.88	576.07	576.01	575.84	575.60	575.32	b575.17	575.33	
1906	575.40	574.26	574.36	575.19	575.45	575.66	575.79	575.80	575.58	c575.45	575.33	57b.21	575.29	
1907	575.38	574.88	574.91	575.53	575.67	576.00	576.16	576.06	575.90	575.76	575.47	575.40	575.60	
1908	575.17	574.53	575.49	575.92	576.16	576.34	d576.40	d576.38	d575.98	575.64	575.23	574.98	575.68	
1909	574.69	573.89	573.98	575.24	576.00	576.05	576.12	576.02	575.73	575.31	575.08	575.75	575.32	
1910	574.59	574.05	575.16	575.24	575.59	575.62	575.60	575.45	575.32	575.20	574.89	574.44	575.10	
1911	573.33	573.36	574.12	574.74	574.84	575.08	575.08	574.95	574.80	574.83	574.60	574.70	574.54	
1912	574.70	574.90	575.14	575.28	575.37	575.51	575.45	575.44	575.55	575.31	575.23	575.02	575.24	
1913	575.46	574.49	574.98	576.34	576.29	576.29	576.29	576.16	575.78	575.50	575.40	575.20	575.68	
1914	574.64	574.52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

a No readings 8-25, incl. b No readings after Dec. 20. c Auto. gage installed Oct. 4th.
d Staff gage means.

Note:—Staff gage zero 575.42 is mean value, by precise levels, from Algonac, 1903 and 1908. P. B. M. Old Club was established by the 1908 levels.

WILLIAMS EXHIBIT 20 Sheet 5.

TABLE No. 5. LAKE ERIE AT CLEVELAND, OHIO.

Monthly mean of water levels above mean tide at New York depending on B. M. 1, 581.41 sea level elevation in feet. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	573.26	572.90	573.30	574.00	574.21	574.18	573.92	573.76	573.42	573.12	573.03	572.87	573.50
1861	572.61	572.33	572.77	573.81	574.24	574.31	574.06	574.10	573.92	573.69	573.67	573.44	573.58
1862	573.43	573.14	573.28	574.18	574.42	574.42	574.39	574.01	573.70	573.32	572.98	573.01	573.69
1863	573.46	573.75	573.69	573.81	573.99	573.85	573.73	573.65	573.26	572.82	572.41	572.38	573.40
1864	572.09	572.24	572.45	572.95	573.65	573.60	573.34	573.07	572.85	572.54	572.37	572.44	572.90
1865	572.01	571.43	571.75	572.47	573.05	573.03	572.99	572.91	572.87	572.57	572.19	572.05	572.44
1866	571.78	571.62	572.01	572.59	572.81	573.07	573.18	572.93	572.87	572.86	572.62	572.63	572.58
1867	572.34	572.02	572.42	572.74	573.26	573.57	573.38	573.07	572.68	572.34	571.84	571.62	572.61
1868	571.42	571.04	571.63	572.46	572.91	573.30	573.27	572.75	572.48	572.03	571.87	571.66	572.23
1869	571.65	571.58	572.06	572.36	572.91	573.30	573.58	573.48	573.21	572.76	572.30	572.65	572.65
1870	572.89	573.12	572.89	573.54	573.75	573.72	572.76	573.71	573.46	573.08	572.78	572.66	573.28
1871	572.45	572.12	572.57	573.05	573.32	573.35	573.33	573.12	572.95	572.28	572.10	571.66	572.60
1872	571.58	571.34	571.25	571.45	571.89	572.26	572.25	572.22	571.99	571.82	571.49	571.26	571.73
1873	571.16	571.17	571.24	572.52	573.19	573.27	573.25	573.19	572.79	572.49	572.29	572.66	572.44
1874	573.05	573.10	573.13	573.30	573.39	573.46	573.49	573.33	572.87	572.43	572.01	571.80	572.95
1875	571.57	571.40	571.54	571.94	572.41	572.84	572.97	572.96	572.82	572.33	572.18	572.40	572.28
1876	572.36	572.92	573.57	574.09	574.41	574.52	574.41	574.11	573.94	573.41	573.49	573.15	573.70
1877	a572.75	572.59	572.36	572.79	573.04	573.12	573.36	573.22	573.14	572.74	572.66	572.74	572.88
1878	572.82	572.96	573.09	573.51	573.77	573.77	573.77	573.53	573.40	573.05	572.85	572.93	573.29
1879	572.51	572.37	572.40	572.76	572.91	573.00	573.03	572.81	572.48	572.25	571.78	572.04	572.53
1880	572.54	572.58	572.72	572.88	573.15	573.26	573.35	573.11	572.88	a572.44	a572.36	a572.02	572.77
1881	a571.61	a571.72	a572.04	572.74	573.14	573.38	573.33	573.01	572.66	572.61	572.43	572.64	572.61
1882	573.11	573.11	573.56	573.78	573.98	574.13	574.06	573.92	573.65	573.20	572.88	572.87	573.48
1883	572.28	572.49	572.68	572.80	573.20	573.96	574.16	574.10	573.79	573.47	573.09	573.12	573.27
1884	572.79	573.05	573.24	573.79	574.06	574.14	573.92	573.76	573.33	573.00	572.52	572.45	573.34
1885	572.27	572.06	571.92	572.74	573.47	573.98	573.94	573.95	573.80	573.70	573.58	573.53	573.24
1886	573.55	572.82	572.63	573.51	573.81	573.91	573.89	573.68	573.44	573.21	572.90	572.85	573.34

1887	572.62	573.04	573.85	573.87	574.05	574.06	573.84	573.52	573.20	572.70	572.43	572.45	573.31	
1888	572.27	572.00	572.10	572.73	572.98	573.11	573.26	573.16	572.72	572.35	572.41	572.29	572.61	
1889	572.31	572.15	571.99	572.34	572.52	572.95	573.15	572.84	572.45	572.03	571.76	572.02	572.38	
1890	572.38	572.67	572.79	573.28	573.62	573.90	573.61	573.17	572.96	572.79	572.76	572.58	573.05	
1891	572.31	572.29	572.75	572.62	572.44	572.58	572.48	572.21	572.03	571.65	571.31	571.28	572.15	
1892	571.31	571.10	571.14	571.70	572.50	573.26	573.38	573.03	572.71	572.15	571.82	571.55	572.14	
1893	571.17	571.25	571.47	572.20	573.04	573.23	572.95	572.61	572.23	571.88	571.46	571.56	572.09	
1894	571.84	571.72	571.75	572.15	572.54	572.85	572.73	572.36	572.19	571.87	571.63	571.56	572.10	
1895	571.23	571.00	571.01	571.26	571.48	571.57	571.46	571.38	571.28	570.80	570.70	570.86	571.17	
1896	570.96	570.88	570.83	571.28	571.66	571.93	571.81	572.02	571.70	571.46	571.09	571.12	571.39	
1897	571.09	571.29	571.66	572.21	572.54	572.64	572.63	572.47	572.19	571.70	571.57	571.54	571.96	
1898	571.59	571.79	572.05	572.63	572.78	572.81	572.59	572.39	572.01	571.81	571.69	571.62	572.14	
1899	571.67	571.46	571.83	572.13	572.44	572.56	572.46	572.21	571.85	571.61	571.62	571.34	571.93	
1900	571.36	571.57	571.92	572.23	572.39	572.47	572.34	572.31	571.99	571.75	571.49	571.45	571.94	
1901	571.35	571.00	570.88	571.29	571.31	571.72	571.91	571.78	571.71	571.33	571.16	571.19	571.39	
1902	571.08	570.63	570.94	571.49	571.86	572.12	572.74	572.72	572.38	572.29	572.02	571.83	571.84	
1903	571.72	571.70	572.28	573.06	573.09	573.06	572.98	572.76	572.59	572.25	571.77	b571.43	572.39	
1904 b	571.32	571.42	572.01	573.13	573.33	573.52	573.41	573.10	572.84	572.49	572.12	571.77	572.54	
1905 b	571.52	571.31	571.18	571.83	572.46	572.98	573.06	572.87	572.63	572.31	571.93	571.91	572.17	
1906 b	571.94	571.93	571.71	572.13	572.40	572.60	572.64	572.63	572.35	572.21	572.17	572.42	572.20	
1907 b	572.76	572.46	572.24	572.71	572.88	573.27	573.31	573.03	572.77	572.69	572.41	572.26	572.73	
1908 b	572.57	572.19	572.06	573.27	573.51	573.51	573.32	573.14	572.68	572.31	571.71	571.42	572.69	
1909 b	571.48	571.46	571.78	572.08	572.90	573.20	573.00	572.80	572.36	571.76	571.61	571.30	572.15	
1910 b	571.25	571.16	571.66	572.08	572.57	572.61	572.40	572.22	572.02	571.88	571.46	571.34	571.87	
1911 b	571.04	571.09	571.06	571.61	571.88	571.94	571.75	571.61	571.52	571.53	571.18	571.42	571.47	
1912 b	571.28	571.08	571.23	572.28	572.59	572.66	572.56	572.49	572.50	572.15	571.92	571.55	572.02	
1913 b	572.23	572.41	572.45	574.03	573.98	573.86	573.57	573.24	572.75	572.43	572.27	572.14	572.95	
1914 b	572.01	571.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	

a Readings interpolated by applying average difference of readings for year to monthly means at Erie, Pa.
b From automatic gage records.

Note.—The Cleveland gage has been frequently inspected and the water levels are considered reliable.

TABLE No. 6. LAKE ONTARIO AT OSWEGO, N. Y.

Monthly means of water levels above mean tide at N. Y., depending on gage zero 244.12 and B. M. "A" 251.90, sea level elevations in feet. U. S. Lake Survey adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Mean
1860	246.58	246.72	246.77	246.80	247.03	247.57	247.82	247.26	246.86	246.67	246.75	246.73	246.96
1861	246.44	246.56	247.01	247.23	248.16	248.54	248.32	248.07	247.60	247.81	247.82	247.61	247.60
1862	247.11	246.69	247.18	248.08	248.38	248.62	248.72	248.26	247.61	247.08	246.73	246.62	247.63
1863	246.77	246.83	246.91	247.63	248.03	248.18	247.77	247.31	246.93	246.74	246.56	246.57	247.19
1864	246.33	246.17	246.26	246.83	247.82	248.12	247.80	247.34	246.81	246.58	246.55	246.65	246.94
1865	247.08	247.23	247.38	247.46	247.62	247.66	247.51	246.90	246.29	246.07	245.82	245.66	246.89
1866	245.46	245.47	245.48	245.96	246.02	245.92	246.84	246.74	246.65	246.52	246.28	246.20	246.13
1867	245.96	245.92	246.62	247.52	248.21	249.48	248.11	247.48	246.98	246.33	246.59	244.83	246.84
1868	244.51	244.61	244.88	245.52	246.12	246.54	246.42	246.13	245.94	245.35	245.20	245.37	245.55
1869	245.22	245.34	245.56	246.09	246.75	246.97	247.29	247.35	247.17	247.08	246.68	246.85	246.53
1870	247.26	247.41	247.41	248.35	248.95	248.63	248.31	247.97	247.28	246.95	246.38	246.13	247.59
1871	246.06	245.89	246.00	246.67	247.12	247.06	246.91	246.46	246.12	245.62	245.21	244.90	246.18
1872	244.73	244.51	244.35	244.84	244.96	245.29	245.35	245.19	244.90	244.74	244.69	244.35	244.82
1873	244.26	244.37	244.50	246.40	246.96	246.91	246.87	246.58	246.15	245.73	245.62	245.79	245.84
1874	246.37	246.74	247.29	247.20	247.17	247.28	247.22	246.97	246.34	245.93	245.40	245.03	246.56
1875	244.72	244.36	244.65	245.41	245.70	245.87	245.93	245.75	245.55	245.27	245.10	244.90	245.27
1876	245.29	245.97	246.52	247.50	248.07	248.29	248.36	247.91	247.30	246.97	246.61	246.40	247.10
1877	245.91	245.63	245.78	246.46	246.54	246.42	246.45	246.20	245.77	245.37	245.25	245.38	245.93
1878	246.48	246.88	246.38	246.64	246.98	246.96	246.72	246.88	a246.59	246.33	246.21	247.00	246.50
1879	246.80	246.46	246.33	246.70	246.81	246.81	246.67	246.31	245.91	245.47	245.10	245.11	246.21
1880	245.30	245.63	245.95	246.15	246.33	246.53	246.52	246.09	245.74	245.36	245.30	245.10	245.88
1881	244.73	244.72	245.39	245.80	245.99	246.20	246.30	245.98	245.39	245.19	245.19	245.20	245.51
1882	245.73	245.91	246.52	246.81	247.02	247.55	247.53	247.19	246.81	246.30	245.87	245.62	246.57
1883	245.30	245.35	245.60	245.15	246.72	247.49	248.03	247.84	247.37	246.94	246.69	246.56	246.68
1884	246.51	246.91	247.58	248.16	248.19	248.09	247.99	247.64	247.22	246.80	246.30	246.15	247.30
1885	246.15	245.88	245.59	246.27	247.07	247.44	247.58	247.44	247.20	247.02	247.07	247.24	246.83
1886	247.60	247.67	247.81	248.45	248.65	248.41	248.04	247.59	247.24	246.83	246.51	246.44	247.60
1887	246.18	246.92	247.48	247.[illegible]	248.20	248.16	247.88	247.38	246.76	246.37	246.02	245.76	247.06
1888	245.45	245.20	245.54	246.17	246.31	246.28	246.14	246.24	245.65	245.46	245.41	245.41	245.82
1889	245.62	245.77	246.06	246.17	246.32	246.63	246.62	246.57	246.07	245.57	245.18	245.79	246.02

1890	246.26	246.60	246.97	247.17	247.52	248.16	247.99	247.33	246.97	246.64	246.71	246.51	247.07
1891	246.19	246.45	246.99	247.47	247.24	246.83	246.55	246.11	245.68	245.04	244.44	244.43	246.12
1892	244.51	244.48	244.61	245.20	245.25	245.81	246.33	246.25	246.04	245.60	245.32	245.20	245.38
1893	244.87	244.77	245.25	245.96	247.13	247.37	247.11	246.57	246.31	245.78	245.37	245.23	245.98
1894	245.56	245.75	246.06	246.10	246.27	246.80	246.60	246.03	245.51	245.26	244.95	244.57	245.79
1895	244.50	244.44	244.33	244.87	245.00	244.89	244.59	244.35	244.00	243.67	243.41	243.43	244.29
1896	243.80	244.27	244.49	245.41	245.43	245.34	245.08	244.94	244.46	244.23	243.97	243.99	244.62
1897	243.87	243.83	244.30	244.96	245.41	245.62	245.61	245.60	245.10	244.47	244.41	244.47	244.80
1898	244.64	245.06	245.48	245.92	246.07	246.18	245.85	245.51	245.09	244.84	244.88	244.90	245.37
1899	244.98	244.88	245.14	245.69	245.94	246.07	245.92	245.46	b244.95	b244.55	b244.42	b244.36	245.20
1900b	b244.63	b244.88	b245.19	245.80	245.99	245.91	245.82	245.54	b245.12	b244.72	b244.56	244.84	245.25
1901b	244.68	244.62	244.39	245.63	b245.91	b245.99	b245.74	b245.42	b245.10	b244.65	b244.28	b244.36	245.06
1902b	244.42	244.30	244.95	245.40	245.47	245.55	245.97	246.11	245.66	245.42	245.05	244.89	245.27
1903b	244.92	245.16	245.75	246.44	246.56	246.44	246.59	246.35	246.07	245.72	245.36	245.11	245.87
1904	244.72	245.00	245.63	247.00	247.61	247.87	247.89	247.64	247.25	246.87	246.36	245.81	246.64
1905	245.79	245.49	245.29	246.13	246.25	246.59	246.98	246.90	246.75	246.45	246.07	245.88	246.21
1906	246.13	246.10	245.91	246.25	246.36	246.41	246.58	246.27	245.81	245.52	245.59	245.71	246.05
1907	246.34	246.47	246.47	246.86	247.09	247.12	247.12	246.90	246.50	246.40	246.33	246.33	246.66
1908	246.73	246.99	247.39	248.02	248.46	248.62	248.34	247.95	247.14	246.44	245.92	245.51	247.29
1909	245.17	245.28	245.70	246.18	247.16	247.30	247.16	246.82	246.28	245.84	245.35	245.21	246.12
1910	244.94	245.03	245.75	245.97	246.42	246.46	246.29	246.05	245.70	245.38	245.15	244.89	245.67
1911	244.77	244.86	244.96	245.44	245.60	245.66	245.54	245.19	244.88	244.62	244.50	244.63	245.05
1912	244.76	244.87	245.10	245.32	246.82	247.34	247.01	246.66	246.36	246.17	246.08	246.11	246.05
1913	246.51	246.75	246.71	247.86	247.97	248.02	247.83	247.31	246.74	246.29	246.06	245.91	247.00
1914	245.60	245.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

a Interpolated. b From records of self-registering gage.

Note—Recent spirit leveling, executed with much care, determined the zero of Oswego staff gage 7.78 ft. below B. M. "A". The value previously used in all reports is 7.75 ft. The gage is cut in the vertical face of cut stone masonry, founded upon solid ledge rock, and is free from any possibility of settlement, hence readings are all reduced for the later value.

The records have been carefully kept and are reliable, but do not always indicate the stage of Lake Ontario, as the gage readings are influenced by high stages of water in Oswego River. These high stages usually occur in the spring months, and give gage readings from 0.2 to 0.3, or even more, above the level of Lake Ontario.

WILLIAMS EXHIBIT 27

Sheet 1 (2 Sheets)
Table 1

TABLE No. DETROIT RIVER AT AMHERSTBURG, ONT.

Monthly means of water levels above mean tide at New York, depending on Gage B. M. as 579.337 sea level elevation in feet. U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1899	.....	.....	.....	.....	.....	572.81	572.76	572.39	572.15	571.98	571.85	571.44	.....
1900	571.63	571.77	572.19	572.45	572.64	572.73	572.57	572.56	572.20	572.03	571.55	571.60	572.16
1901	571.57	571.19	571.12	571.59	571.56	572.04	572.20	572.15	572.03	571.59	571.19	571.62	571.64
1902	571.21	570.86	571.13	571.63	572.09	572.34	572.99	573.00	572.64	572.49	572.20	571.98	572.05
1903	571.81	571.81	572.44	573.20	573.34	573.22	573.18	572.99	572.82	572.39	571.84	571.67	572.56
1904	571.56	571.61	572.20	573.28	573.60	573.74	573.68	573.38	573.08	572.73	572.24	572.05	572.76
1905	571.78	571.45	571.55	572.03	572.76	573.22	573.30	573.18	572.40	572.45	572.02	572.05	572.39
1906	572.10	572.14	572.00	572.43	572.68	572.92	573.02	572.97	572.70	572.38	572.32	572.48	572.51
1907	572.91	572.66	572.47	572.94	573.17	573.63	573.64	573.41	573.10	572.82	572.51	572.41	572.97
1908	572.72	572.29	572.90	573.40	573.73	573.77	573.62	573.47	572.99	572.58	571.83	571.58	572.91
1909	571.75	571.64	571.81	572.43	573.09	573.48	573.22	573.10	572.64	571.94	571.57	571.77	572.40
1910	571.58	571.50	571.76	572.31	572.76	572.90	572.80	572.52	572.30	572.01	571.52	571.52	572.12
1911	571.25	571.04	571.22	571.89	572.10	572.18	572.00	571.91	571.83	571.78	571.24	571.61	571.67
1912	571.61	571.47	571.71	572.42	572.79	572.89	572.81	572.75	572.74	572.33	571.90	571.69	572.28
Mean to 1905, incl.													

Note.—The water level at this station are all from records of self-registering gage. In the adjustment of levels made in 1903, the correction of levels of Lake Erie ports with those of the upper lakes was made by comparison of water levels with those at this station, making the elevation of gage B. M. 579.172. Subsequent precise levels from P. b. M. Trenton (1877) using the adjusted elevation gives the elevation of Gage B. M. 579.337. The later value is adopted, giving the water levels at Amherstburg on the same plane as other stations on Detroit River and above, but probably about 0.15 ft. too high as compared with Lake Erie gages. The slope of the river from Amherstburg to Lake Erie has not been definitely determined, but is assumed to be from 0.10 to 0.15 feet.

TABLE No. LAKE ST. CLAIR AT WINDMILL PT.

Monthly means of water levels above mean tide at New York, depending on P. B. M. 12 as 584.22, sea level elevation in feet, U. S. Lake Survey level adjustment of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1897	574.28	574.64	574.57	574.75	575.20	575.11	575.22	575.15	574.93	574.58	574.47	574.22	574.77
1898	574.20	.....	574.76	575.01	575.11	575.26	575.30	575.19	574.90	574.64	574.65	574.68	.....
1899	574.65	574.57	573.59	574.32	574.88	575.18	575.30	575.22	574.93	574.65	574.49	574.10	574.66
1900	574.03	574.24	574.67	574.64	574.79	574.99	575.01	575.06	574.89	574.74	574.52	574.41	574.67
1901	574.01	573.06	573.32	572.69	573.94	574.81	575.04	575.07	574.89	574.56	574.30	574.47	574.18
1902	573.31	572.96	573.96	574.22	.....	.....	575.50	575.41	575.08	574.92	574.62	574.64	.....
1903	574.69	574.40	574.75	575.31	575.27	575.38	575.44	575.36	575.29	575.04	574.54	574.94	575.03
1904	573.74	573.92	574.92	575.64	575.61	575.92	575.97	575.82	575.60	575.31	574.94	574.89	575.19
1905	575.78	573.50	573.57	574.73	575.11	575.66	575.80	575.74	575.52	575.18	574.84	574.73	574.87
1906	574.86	573.99	574.00	574.88	575.20	575.42	575.58	575.54	575.30	575.08	574.99	574.89	574.98
1907	574.94	574.65	574.60	575.24	575.44	575.78	575.90	575.76	575.51	575.40	575.05	574.96	575.27
1908	574.71	574.00	575.04	575.56	575.88	576.07	576.10	576.06	575.70	575.34	574.70	574.45	575.30
1909	574.32	573.49	573.62	574.85	575.69	575.85	575.83	575.70	575.35	574.82	574.69	575.27	574.96
1910	574.36	573.67	574.71	574.88	575.22	575.34	575.31	575.07	574.97	574.74	574.41	574.01	574.72
	See Note												See Note
1911	573.07	572.94	573.77	574.44	574.60	574.83	574.73	574.64	574.46	574.43	574.13	574.24	574.13
1912	574.46	574.45	574.84	574.98	575.09	575.22	575.16	575.10	575.18	574.90	574.73	574.43	574.85
1913	574.92	574.23	574.56	576.09	576.06	576.04	575.99	575.81	575.33	574.98	574.85	574.70	575.30
Means to 1905, incl.													

Note.—The water levels at this station are reduced from tri-daily staff-gage readings made under the direction of the U. S. Lake Survey Office, Detroit. The readings from Jan., 1911, to Mar., 1912, are in doubt, as the new float gage furnished the gage reader in former month was injured soon after it was received, and this was not discovered until the latter month. Readings for this period have been corrected +0.13 ft. determined by comparison with St. Clair Flats Canal, Fort Wayne, and Amherstburg.

WILLIAMS EXHIBIT 27

Sheet 2 (2 Sheets.)
Table 3

TABLE No. DETROIT RIVER AT FORT WAYNE

Monthly means of water levels above mean tide at New York, depending on B. M. Warehouse, as 584.317, U. S. Lake Survey adjusted levels of 1903.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1905	.....	.....	.....	.....	.....	.....	.....	.....	.....	574.30	574.01	573.92	.....
1906	574.03	573.53	573.29	574.08	574.38	574.62	574.78	574.74	574.54	574.34	574.15	574.16	574.22
1907	574.33	574.16	573.94	574.43	574.63	575.03	575.13	575.00	574.70	574.63	574.28	574.16	574.54
1908	574.06	573.52	574.40	574.86	575.21	575.37	575.38	575.30	574.89	574.56	573.94	573.68	574.60
1909	573.63	573.06	573.10	574.14	574.91	575.14	575.08	574.98	574.66	574.04	573.90	574.34	574.25
1910	573.72	573.23	573.96	574.18	574.53	574.65	574.60	574.39	574.26	574.05	573.65	573.41	574.05
1911	572.51	572.40	572.98	573.75	573.89	574.08	573.97	573.93	573.78	573.72	573.29	573.52	573.48
1912	573.75	573.62	574.07	574.29	574.43	574.56	574.42	574.38	574.43	574.10	573.86	573.58	574.12
1913	574.16	573.79	573.98	575.36	575.38	575.34	575.23	575.04	574.61	574.28	574.07	.....	.....
1914	.....	573.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Williams Exhibit 27.

WILLIAMS EXHIBIT 28. Sheet 1
8 Sheets

ELEVATIONS OF WATER SURFACE OF LAKE ST. CLAIR

From record of self-registering gage at

ST. CLAIR FLATS, MICH.

In terms of U. S. Lake Survey adjusted levels of 1903.

	1909			1910			
Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
1	575.55	575.08a	575.11	576.43	573.83	574.46a	575.08
2	575.54	575.13a	575.10	576.19	573.84	574.55	575.06
3	575.54	575.13	575.08	576.05	573.90	574.66	575.07
4	575.52a	575.09	575.06	575.90	573.91	574.75	575.08
5	575.52a	575.09	575.16	575.67	573.95	574.88	575.09
6	575.52	575.09	575.08	575.43	574.02	575.09	575.12
7	575.50	575.08	575.10	575.24	574.05	575.26	575.10
8	575.48	575.06	575.25	575.05	574.05	575.33	575.13
9	575.46	575.09	575.17	574.90	574.06	575.40	575.13
10	575.43	575.08	575.11	574.79	574.07	575.43	575.13
11	575.54	575.08	575.12	574.65	574.06	575.45	575.09
12	575.59	575.04	575.22	574.54	574.05	575.43	575.07
13	575.33	575.06	575.36	574.45	574.05	575.46	575.09
14	575.24	575.06	575.37	574.47	574.05	575.48	575.10
15	575.22	575.05	575.29	574.45	574.04	575.47	575.10
16	575.23	575.16	575.31	574.38	574.02	575.40	575.11
17	575.19	575.09	575.40	574.31a	574.03	575.40	575.19
18	575.19	575.02	575.39	574.28a	574.09	575.42	575.19
19	575.21	575.08	575.51	574.22	574.13	575.36	575.17
20	575.24	575.05	575.77	574.17	574.16	575.28	575.36
21	575.31	574.97	575.97	574.13	574.20	575.28	575.49
22	575.23	575.06	576.24	574.19	574.24	575.27	575.53
23	575.17	575.22	576.50	574.11	574.26	575.27	575.58
24	575.24	575.24	576.64	574.06	574.27	575.25	575.48
25	575.31	575.23	576.80	574.01	574.27	575.23	575.52
26	575.22	575.21	577.01	573.97	574.27a	575.19	575.64
27	575.18	575.15	577.04	573.92	574.2va	575.17	575.67
28	575.15	575.10	577.04	573.87	574.37	575.11	575.68
29	575.14	575.12	577.10	573.84	.....	575.10	575.65
30	575.15	575.12	577.03	573.81a	.....	575.08	575.56
31	575.11	.....	576.73	573.82a	.....	575.10	.....
Mean	575.33	575.10	575.78	574.62	574.09	575.19	575.28

Note.—Elevations previous to March, 1910, are referred to zero of reference gage as 576.20. Inspection of Dec. 13, 1909, corrects elevation of zero by—0.01—576.19. Readings in December, January and February should therefore be corrected by—0.01, to give correct elevations.

a=Mean of partial day only.

WILLIAMS EXHIBIT 28. Sheet 2.

U. S. LAKE SURVEY.

Daily Mean Elevations of Water Surface at

ST. CLAIR FLATS CANAL.

In Feet above Mean Tide at New York. Adjusted Levels, 1903.

Day	1900 April	1900 May	1900 June	1900 July	1900 August	1900 Sept.	REMARKS.
1	574.25	574.97	575.33	575.42	575.63	575.32	
2	574.25	575.03	575.33	575.45	575.63	575.32	
3	574.28	575.02	575.63	575.47	575.62	575.27	
4	574.32	575.03	575.33	575.47	575.63	575.27	
5	574.27	575.03	575.34	575.42	575.63	575.27	
6	574.27	575.03	575.35	575.42	575.63	575.22	
7	574.30	575.07	575.42	575.50	575.62	575.22	
8	574.50	575.07	575.42	575.53	575.63	575.22	
9	574.53	575.07	575.43	575.53	575.62	575.22	
10	574.29	575.07	575.43	575.53	575.57	575.22	
11	574.34	575.07	575.42	575.57	575.57	575.22	
12	574.72	575.07	575.43	575.57	575.57	575.22	
13	574.49	575.07	575.43	575.57	575.57	575.22	
14	574.67	575.07	575.43	575.62	575.52	575.22	
15	574.70	575.07	575.42	575.63	575.53	575.22	
16	574.92	575.07	575.42	575.63	575.53	575.22	
17	575.02	575.15	575.42	575.62	575.42	575.23	
18	575.02	575.17	575.43	575.62	575.43	575.23	
19	575.02	575.17	575.42	575.63	575.43	575.22	
20	575.02	575.14	575.43	575.60	575.42	575.17	
21	575.02	575.22	575.42	575.62	575.42	575.12	
22	575.02	575.22	575.42	575.62	575.42	575.13	
23	575.03	575.22	575.43	575.62	575.42	575.12	
24	575.02	575.22	575.43	575.62	575.42	575.12	
25	574.97	575.22	575.42	575.62	575.43	575.07	
26	574.97	575.22	575.42	575.62	575.42	575.12	
27	574.97	575.22	575.43	575.62	575.42	575.12	
28	574.97	575.27 Interpolated	575.43	575.62	575.43	575.12	
29	574.97	575.27 Interpolated	575.42	575.62	575.43	575.12	
30	574.97	575.27 Interpolated	575.43	575.63	575.43	575.12	
31	.....	575.27 Interpolated	.....	575.62	575.42	.....	
Mean	574.71	575.13	575.40	575.57	575.51	575.19	

Daily mean values during 1900, 1901 and 1902, are from tri-daily staff-gage readings.

1903 values are from self-registering gage records. All values are in terms of the 1903 determination of zero, 575.418.

WILLIAMS EXHIBIT 28.

Sheet 2—Cont'd

Day	1899 October	1899 November	1901 May	1901 June			REMARKS.
1	575.07	574.92	573.31	574.97	.....	.....	
2	575.04	574.92	573.32	575.03	.....	.....	
3	575.03	574.89	573.30	575.03	.....	.....	
4	575.03	574.82	573.29	575.02	.....	.....	
5	574.97	574.82	573.16	575.02	.....	.....	
6	574.92	574.82	573.30	575.02	.....	.....	
7	574.93	574.82	573.31	575.02	.....	.....	
8	574.92	574.82	573.36	575.02	.....	.....	
9	574.93	574.82	573.94	575.03	.....	.....	
10	574.92	574.83	574.13	575.02	.....	.....	
11	574.91	574.83	574.26	575.02	.....	.....	
12	574.92	574.82	574.44	575.02	.....	.....	
13	574.92	574.72	574.53	575.02	.....	.....	
14	574.92	574.72	574.60	575.02	.....	.....	
15	574.92	574.72	574.60	575.10	.....	.....	
16	574.92	574.72	574.64	575.13	.....	.....	
17	574.92	574.72	574.62	575.07	.....	.....	
18	574.92	574.72	574.66	575.12	.....	.....	
19	574.93	574.73	574.72	575.13	.....	.....	
20	574.83	574.73	574.87	575.13	.....	.....	
21	574.83	574.72	574.87	575.13	.....	.....	
22	574.83	574.72	574.83	575.12	.....	.....	
23	574.83	574.72	574.82	575.13	.....	.....	
24	574.82	574.73	574.82	575.12	.....	.....	
25	574.83	574.73	574.83	575.13	.....	.....	
26	574.83	574.72	574.83	575.17	.....	.....	
27	574.82	574.72	574.94	575.23	.....	.....	
28	574.83	574.72	574.92	575.23	.....	.....	
29	574.83	574.72	574.92	575.23	.....	.....	
30	574.83	574.72	574.92	575.23	.....	.....	
31	574.82	.....	574.92	.....	.....	.....	
Mean	574.90	574.77	574.33	575.08	.....	.....	

WILLIAMS EXHIBIT 28. Sheet 6.

U. S. LAKE SURVEY.

Daily Mean Elevations of Water Surface at

ST. CLAIR FLATS CANAL.

In Feet Above Mean Tide at New York, Adjusted Levels, 1903.

Day	1900 June	1900 July	1900 August	1900 Sept.	1900 Oct.	1900 Nov.	Remarks
1	575.07	575.22	575.42	575.32	575.13	575.19	
2	575.10	575.22	575.42	575.32	575.12	575.12	
3	575.10	575.22	575.42	575.32	575.12	575.07	
4	575.22	575.22	575.42	575.32	575.12	575.02	
5	575.29	575.22	575.42	575.32	575.12	575.02	
6	575.10	575.22	575.42	575.32	575.09	575.02	
7	575.17	575.22	575.27	575.32	575.02	574.97	
8	575.29	575.22	575.22	575.22	575.07	574.97	
9	575.22	575.22	575.32	575.27	575.12	574.97	
10	575.22	575.22	575.32	575.32	575.12	574.92	
11	575.22	575.22	575.32	575.27	575.12	574.92	Daily mean values during 1899, 1900 and 1902, are from tri-daily staff-gage readings. 1908 values are from self-registering gage records. All values are in terms of the 1906 determination of zero, 575.413.
12	575.22	575.22	575.34	575.32	575.12	574.92	
13	575.20	575.22	575.32	575.26	575.12	574.92	
14	575.29	575.22	575.32	575.27	575.12	574.92	
15	575.22	575.22	575.32	575.26	575.12	574.92	
16	575.22	575.22	575.32	575.21	574.99	574.92	
17	575.22	575.27	575.32	575.14	575.06	574.92	
18	575.22	575.22	575.32	575.12	575.07	574.92	
19	575.22	575.22	575.32	575.17	575.07	574.92	
20	575.26	575.22	575.32	575.22	575.07	574.92	
21	575.22	575.22	575.32	575.17	575.02	574.92	
22	575.22	575.27	575.32	575.12	574.92	574.87	
23	575.22	575.27	575.32	575.12	575.02	574.87	
24	575.22	575.34	575.22	575.12	575.02	574.87	
25	575.22	575.37	575.42	575.07	575.02	574.87	
26	575.22	575.37	575.37	575.02	575.02	574.87	
27	575.22	575.37	575.32	575.06	575.02	574.87	
28	575.22	575.42	575.22	575.12	575.02	574.87	
29	575.22	575.42	575.22	575.12	575.02	574.87	
30	575.22	575.42	575.22	575.12	575.02	574.87	
31	.....	575.42	575.32	.....	575.02	.....	
Mean	575.21	575.29	575.34	575.23	575.07	574.94	

Day	1900 Dec.	1902 Aug.	1902 Sept.	1902 Nov.	1902 Dec.		Remarks
1	574.87	575.82	575.42	575.42	575.12	.....	
2	574.87	575.82	575.42	575.42	575.10	.....	
3	574.87	575.82	575.32	575.42	575.16	.....	
4	574.87	575.82	575.29	575.24	575.06	.....	
5	574.87	575.74	575.22	575.46	575.01	.....	
6	574.87	575.79	575.22	575.42	575.01	.....	
7	574.87	575.73	575.29	575.27	575.06	.....	
8	574.87	575.72	575.32	575.26	575.04	.....	
9	574.87	575.72	575.32	575.27	574.97	.....	
10	574.87	575.72	575.32	575.22	574.97	.....	
11	574.87	575.72	575.27	575.21	574.99	.....	
12	574.87	575.72	575.29	575.27	575.09	.....	
13	574.84	575.72	575.32	575.23	575.09	.....	
14	574.82	575.67	575.32	575.23	575.09	.....	
15	574.77	575.67	575.32	575.26	575.09	.....	
16	574.77	575.57	575.22	575.14	574.99	.....	
17	574.77	575.62	575.22	575.10	574.92	.....	
18	574.77	575.57	575.22	575.09	574.97	.....	
19	574.77	575.56	575.27	575.07	575.06	.....	
20	574.73	575.52	575.27	575.11	574.99	.....	
21	574.73	575.53	575.22	575.10	574.96	.....	
22	574.73	575.52	575.22	575.09	574.96	.....	
23	574.72	575.52	575.27	575.09	574.91	.....	
24	574.72	575.52	575.27	575.07	574.96	.....	
25	574.74	575.52	575.42	575.09	574.90	.....	
26	574.73	575.42	575.32	575.21	574.99	.....	
27	574.73	575.46	575.32	575.12	574.94	.....	
28	574.73	575.42	575.32	575.12	574.94	.....	
29	574.73	575.42	575.32	575.09	574.97	.....	
30	574.73	575.42	575.32	575.07	574.91	.....	
31	574.73	575.42	.....	.....	574.89	.....	
Mean	574.80	575.62	575.34	575.23	574.98	.....	

WILLIAMS EXHIBIT 28. Sheet 4.

U. S. LAKE SURVEY.

Daily Mean Elevations of Water Surface at

ST. CLAIR FLATS CANAL.

In Feet Above Mean Tide at New York, Adjusted Levels, 1903.

Day	1899 April	1900 May	1900 June	1900 July	1900 August	1900 Sept.	Remarks
1	574.26	574.97	575.22	575.42	575.62	575.52	
2	574.32	575.02	575.22	575.46	575.62	575.32	
3	574.30	575.02	575.22	575.47	575.62	575.27	
4	574.32	575.02	575.22	575.47	575.62	575.27	
5	574.27	575.02	575.24	575.42	575.62	575.27	
6	574.27	575.02	575.26	575.42	575.62	575.22	
7	574.30	575.07	575.42	575.50	575.62	575.22	
8	574.50	575.07	575.42	575.52	575.62	575.22	
9	574.52	575.07	575.42	575.52	575.62	575.22	
10	574.30	575.07	575.42	575.52	575.57	575.22	
11	574.24	575.07	575.42	575.57	575.57	575.22	
12	574.72	575.07	575.42	575.57	575.57	575.22	
13	574.42	575.07	575.42	575.57	575.57	575.22	
14	574.67	575.07	575.42	575.62	575.52	575.22	
15	574.70	575.07	575.42	575.62	575.52	575.22	
16	574.92	575.07	575.42	575.62	575.52	575.22	
17	575.02	575.12	575.42	575.62	575.42	575.22	
18	575.02	575.17	575.42	575.62	575.42	575.22	
19	575.02	575.17	575.42	575.62	575.42	575.22	
20	575.02	575.14	575.42	575.60	575.42	575.17	
21	575.02	575.22	575.42	575.62	575.42	575.12	
22	575.02	575.22	575.42	575.62	575.42	575.12	
23	575.02	575.22	575.42	575.62	575.42	575.12	
24	575.02	575.22	575.42	575.62	575.42	575.12	
25	574.97	575.22	575.42	575.62	575.42	575.07	
26	574.97	575.22	575.42	575.62	575.42	575.12	
27	574.97	575.22	575.42	575.62	575.42	575.12	
28	574.97	575.27 Interpolated	575.42	575.62	575.42	575.12	
29	574.97	575.27 Interpolated	575.42	575.62	575.42	575.12	
30	574.97	575.27 Interpolated	575.42	575.62	575.42	575.12	
31	.....	575.27 Interpolated	.....	575.62	575.42	.....	
Mean	574.71	575.13	575.40	575.57	575.51	575.19	

Daily mean values during 1899, 1900 and 1903 are from tri-daily staff-gage readings.

1908 values are from self-registering gage records.

All values are in terms of the 1908 determination of zero, 575.418.

Day	1899 Oct.	1899 Nov.					Remarks
1	575.07	574.92	.....	.....	.....	.....	
2	575.04	574.92	.....	.....	.....	.....	
3	575.02	574.86	.....	.....	.....	.....	
4	575.02	574.83	.....	.....	.....	.....	
5	574.97	574.83	.....	.....	.....	.....	
6	574.92	574.83	.....	.....	.....	.....	
7	574.92	574.82	.....	.....	.....	.....	
8	574.92	574.83	.....	.....	.....	.....	
9	574.92	574.83	.....	.....	.....	.....	
10	574.92	574.83	.....	.....	.....	.....	
11	574.92	574.83	.....	.....	.....	.....	
12	574.92	574.83	.....	.....	.....	.....	
13	574.92	574.72	.....	.....	.....	.....	
14	574.92	574.72	.....	.....	.....	.....	
15	574.92	574.72	.....	.....	.....	.....	
16	574.92	574.72	.....	.....	.....	.....	
17	574.92	574.72	.....	.....	.....	.....	
18	574.92	574.72	.....	.....	.....	.....	
19	574.92	574.72	.....	.....	.....	.....	
20	574.92	574.72	.....	.....	.....	.....	
21	574.88	574.72	.....	.....	.....	.....	
22	574.83	574.72	.....	.....	.....	.....	
23	574.83	574.72	.....	.....	.....	.....	
24	574.83	574.72	.....	.....	.....	.....	
25	574.83	574.72	.....	.....	.....	.....	
26	574.83	574.72	.....	.....	.....	.....	
27	574.83	574.72	.....	.....	.....	.....	
28	574.83	574.72	.....	.....	.....	.....	
29	574.83	574.72	.....	.....	.....	.....	
30	574.81	574.72	.....	.....	.....	.....	
31	574.81	.....	.....	.....	.....	.....	
Mean	574.90	574.77	.....	.....	.....	.....	

WILLIAMS EXHIBIT 28 Sheet 1.
U. S. LAKE SURVEY.
Daily Mean Elevations of Water Surface at
HARBOR BEACH, MICH.
In Feet Above Mean Tide at New York, Adjusted Levels, 1903.

Day	1900 April	1900 May	1900 June	1900 July	1900 August	1900 Sept.	REMARKS.
1	579.8	580.21	580.61	580.85	581.04	580.81	
2	579.9	580.31	580.62	581.01	581.06	580.71	
3	579.8	580.18	580.58	581.01	581.11	581.18	
4	579.8	580.06	580.38	580.91	581.11	580.78	
5	579.7	580.28	580.48	581.06	581.14	580.74	
6	579.6	580.31	580.65	581.05	581.18	580.94	
7	579.7	580.28	580.75	580.81	581.04	580.38	
8	580.0	580.31	580.88	581.31	581.06	580.84	
9	579.9	580.41	580.71	581.21	580.91	580.94	
10	579.7	580.18	580.71	581.11	580.91	580.81	
11	579.5	580.41	580.65	581.06	580.84	580.78	
12	579.7	580.34	580.65	581.11	581.11	581.04	
13	579.9	580.51	580.78	581.11	581.21	581.11	
14	579.4	580.84	580.75	581.04	581.01	580.88	
15	579.8	580.38	580.81	581.04	581.04	580.81	
16	579.9	580.21	581.05	581.18	581.01	580.61	
17	579.8	580.28	580.65	581.18	580.96	580.78	
18	579.8	580.46	580.78	581.18	580.91	580.78	
19	579.9	580.06	580.88	581.01	580.91	581.01	
20	580.0	580.91	580.95	581.06	580.94	580.74	
21	579.9	580.51	580.91	581.11	580.94	580.81	
22	580.0	580.51	580.75	581.14	581.21	580.81	
23	580.1	580.48	580.91	580.91	580.86	580.84	
24	579.9	580.44	580.81	580.96	580.94	580.78	
25	580.1	580.41	580.96	581.04	581.04	580.71	
26	580.1	580.31	580.86	581.01	580.84	580.74	
27	579.9	580.48	580.88	581.21	580.64	580.64	
28	579.8	580.41	581.01	581.08	580.91	580.41	
29	580.1	580.44	580.91	581.11	580.81	580.81	
30	580.0	580.71	581.05	581.41	580.81	580.74	
31	.....	580.55	.....	581.11	580.84	.....	
Mean	579.85	580.39	580.79	581.04	580.90	580.70	

During 1900, the daily means are from the daily staff gage readings.
1901 are from self-registering gage records

Day	1900 October	1900 Nov.	1901 May	1901 June			REMARKS.
1	580.64	580.68	580.63	580.94	.....	.....	
2	580.31	580.26	580.73	580.92	.....	.....	
3	580.34	580.51	580.77	580.93	.....	.....	
4	580.51	580.41	580.70	580.80	.....	.....	
5	580.48	580.41	580.72	580.75	.....	.....	
6	580.44	580.21	580.99	580.90	.....	.....	
7	580.38	580.31	580.68	581.03	.....	.....	
8	580.31	580.31	580.75	581.11	.....	.....	
9	580.34	580.38	580.79	580.98	.....	.....	
10	580.14	580.34	580.74	580.83	.....	.....	
11	580.34	580.34	580.81	580.87	.....	.....	
12	580.31	580.34	580.75	580.98	.....	.....	
13	580.21	580.18	580.93	580.87	.....	.....	
14	580.61	580.18	580.85	580.93	.....	.....	
15	580.31	580.31	580.79	580.87	.....	.....	
16	580.11	580.14	580.75	580.84	.....	.....	
17	580.08	579.71	580.78	580.80	.....	.....	
18	580.34	580.21	580.53	580.93	.....	.....	
19	580.51	580.28	580.91	580.90	.....	.....	
20	580.48	580.11	580.81	580.92	.....	.....	
21	580.21	580.94	580.81	580.93	.....	.....	
22	579.88	580.24	580.61	580.85	.....	.....	
23	580.14	580.21	580.85	581.09	.....	.....	
24	580.31	580.31	580.97	580.89	.....	.....	
25	580.34	580.34	580.97	580.99	.....	.....	
26	580.56	580.21	580.98	580.94	.....	.....	
27	580.48	580.14	580.93	580.94	.....	.....	
28	580.77	580.11	580.95	580.94	.....	.....	
29	580.61	580.01	580.96	580.96	.....	.....	
30	580.51	580.18	580.86	581.07	.....	.....	
31	580.34	.....	580.97	.....	.....	.....	
Mean	580.38	580.24	580.81	580.91	.....	.....	

WILLIAMS EXHIBIT 28. Sheet 6.

U. S. LAKE SURVEY.

Daily Mean Elevations of Water Surface at

HARBOR BEACH, MICH.

In Feet Above Mean Tide at New York. Adjusted Levels, 1903.

Day	1900 June	1900 July	1900 August	1900 Sept.	1900 Oct.	1900 Nov.	REMARKS
1	580.11	580.34	580.68	580.66	580.64	580.28	
2	580.24	580.18	580.61	580.48	580.54	580.84	
3	580.44	580.28	580.64	580.94	580.61	580.54	
4	580.34	580.41	580.54	580.74	580.64	580.84	
5	580.21	580.38	580.61	580.61	580.68	580.71	
6	580.21	580.34	580.61	580.98	580.68	580.74	
7	580.31	580.41	580.61	580.74	580.84	580.61	
8	580.24	580.51	580.68	580.74	580.94	580.51	
9	580.38	580.58	580.61	580.71	580.78	580.61	
10	580.21	580.48	580.71	580.61	580.81	580.64	
11	580.41	580.54	580.71	580.64	580.88	580.58	
12	580.31	580.64	580.61	580.96	580.81	580.71	
13	580.28	580.58	580.68	580.91	580.74	580.91	
14	580.34	580.38	580.54	580.88	580.74	580.71	
15	580.31	580.48	580.58	580.41	580.71	580.91	
16	580.28	580.58	580.61	580.71	581.14	580.71	During 1900, the daily means are from tri-daily staff gage readings.
17	580.31	580.41	580.58	581.08	580.68	580.41	
18	580.34	580.71	580.54	580.78	580.98	580.68	
19	580.34	580.57	580.61	580.51	580.64	580.34	
20	580.38	580.64	580.68	580.51	580.56	580.41	
21	580.21	580.81	580.56	580.74	580.48	580.68	
22	580.24	580.61	580.68	580.74	580.48	580.78	
23	580.28	580.66	580.54	580.64	580.44	580.84	
24	580.36	580.64	580.61	580.64	580.71	580.71	
25	580.31	580.71	580.61	580.51	580.54	580.84	
26	580.21	580.74	580.71	580.74	580.38	580.88	
27	580.41	580.66	580.66	580.64	580.74	580.58	
28	580.24	580.61	580.74	580.71	580.48	580.54	
29	580.64	580.61	580.74	580.71	580.54	580.64	
30	580.51	580.61	580.64	580.81	580.48	580.58	
31	.....	580.78	580.71	.....	580.21	.....	
Mean	580.30	580.53	580.63	580.73	580.66	580.66	

Day	1900 Dec.	1902 Aug.	1902 Sept.	1902 Nov.	1902 Dec.		REMARKS
1	580.58	580.90	580.76	580.71	580.61	.....	
2	580.48	580.83	580.98	580.66	580.98	.....	
3	580.41	580.96	580.56	580.70	580.34	.....	
4	580.51	580.96	580.93	580.66	580.34	.....	
5	580.81	580.75	580.66	580.85	580.37	.....	
6	580.64	580.90	580.30	580.71	579.99	.....	
7	580.61	580.90	580.60	580.70	580.16	.....	
8	580.38	580.94	580.53	580.58	580.33	.....	
9	581.01	580.86	580.76	580.90	580.33	.....	
10	580.71	580.74	580.50	580.51	580.10	.....	
11	580.71	581.01	580.89	580.50	580.14	.....	
12	580.44	580.96	580.66	580.58	580.35	.....	
13	580.51	580.70	580.63	580.49	580.22	.....	
14	580.66	580.83	580.58	580.38	580.17	.....	
15	580.44	580.80	580.32	580.35	580.25	.....	1902 and 1908 values are from self-registering gage records.
16	580.38	580.83	580.41	580.52	580.27	.....	
17	580.14	580.85	580.29	580.45	580.05	.....	
18	580.34	580.70	580.44	580.47	580.03	.....	
19	580.41	580.79	580.58	580.38	580.21	.....	
20	580.58	580.79	580.43	580.34	580.30	.....	
21	580.14	580.90	580.40	580.24	580.39	.....	
22	580.06	580.94	580.45	580.13	580.23	.....	
23	580.04	580.88	580.49	580.16	580.02	.....	
24	580.24	580.83	580.44	580.05	580.01	.....	
25	580.41	580.78	580.14	579.99	580.14	.....	
26	580.24	580.79	580.27	580.14	580.23	.....	
27	580.24	580.82	580.29	580.68	580.23	.....	
28	580.48	580.73	580.45	580.46	580.23	.....	
29	580.41	580.70	580.80	580.37	580.02	.....	
30	580.54	580.65	580.45	580.11	579.76	.....	
31	580.84	580.86	.....	.....	580.40	.....	
Mean	580.46	580.83	580.52	580.46	580.21	.....	

WILLIAMS EXHIBIT 28. Sheet/

ELEVATIONS OF WATER SURFACE OF LAKE HURON.

From record of self-registering gage at

HARBOR BEACH, MICH.

In terms of U. S. Lake Survey adjusted levels of 1903.

	1909			1910			
Day	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
1	580.82	580.02	580.03	579.84	579.95a	579.90	580.06
2	580.66	580.10	579.90	580.24	597.97	579.91	579.99
3	580.58	580.31	579.96	580.28	580.01	579.95	579.87
4	580.55	580.35	580.01	580.31	580.07	579.92	579.85
5	580.53	580.17	579.78	579.44	580.34	579.91	579.90
6	580.52	580.07	579.99	580.11	580.23	579.83	580.06
7	580.51	579.86	580.35	579.99	579.92	580.15	580.32
8	580.43	580.29	580.23	579.94	580.00	580.23	580.06
9	580.41	580.02	580.41	580.12	580.06	580.11	580.08
10	580.31	579.94	580.40	579.91	580.04	580.02	580.13
11	580.27	579.98	580.12	579.91	579.81	579.91	580.09
12	580.11	580.26	579.76	579.96	579.84	579.88	580.10
13	580.45	579.99	579.39	579.98	579.97	580.26	580.10
14	580.58	579.91	579.86	579.89	580.02a	580.51	580.06
15	580.54	580.33	580.29	579.89	579.88a	580.04	579.95
16	580.58	580.06	580.12	579.92	579.90	580.12	579.90
17	580.52	580.05	580.03	579.83	580.08	580.00	579.93
18	580.43	580.35	580.27	579.88	580.05	579.87	580.09
19	580.39	580.06	580.21	580.14	579.94	579.78	580.30
20	580.22	580.02	580.09	579.79a	579.86	580.07	580.43
21	580.02	580.31	580.03	580.02	580.00	579.94	580.19
22	580.54	580.40	580.30	580.45	580.02	580.03	580.11
23	580.53	580.22	580.23	580.14	580.04	579.88	579.93
24	580.33	580.06	580.11	580.09	580.05	579.78	580.28
25	580.20	580.10	580.10	580.02	579.96	580.13	580.37
26	580.23	580.05	580.11	579.70	579.61	579.99	580.24
27	580.50	579.90	580.12	579.88	579.90	579.76	580.31
28	580.44	580.26	580.12	580.16c	579.99	579.86	580.23
29	580.24	580.15	580.16	579.86c	.....	579.96	579.95
30	579.97	580.08	580.04	580.05c	.....	579.93	580.22
31	580.16	.....	579.98	580.00c	.....	580.06	.....
Mean	580.40	580.12	580.06	579.99	579.96	579.99	580.10

Note:—a=Mean of partial day only.

c=No record, intake of float pipe clogged. Readings given are single readings of reference gage.

WILLIAMS EXHIBIT 28. Sheet 3

U. S. LAKE SURVEY.

Daily Mean Elevations of Water Surface at

HARBOR BEACH, MICH.

In Feet above Mean Tide at New York, Adjusted Levels, 1903.

Day	1899 April	1899 May	1899 June	1899 July	1899 August	1899 Sept.	REMARKS.
1	579.8	580.21	580.61	580.85	581.04	580.81	
2	579.9	580.31	580.68	581.01	581.08	580.71	
3	579.8	580.18	580.58	581.01	581.11	581.18	
4	579.8	580.06	580.38	580.91	581.11	580.78	
5	579.7	580.28	580.48	581.06	581.14	580.74	
6	579.6	580.31	580.65	581.05	581.18	580.94	
7	579.7	580.28	580.78	580.81	581.04	580.38	
8	580.0	580.31	580.88	581.31	581.08	580.84	
9	579.9	580.41	580.71	581.31	580.81	580.94	
10	579.7	580.16	580.71	581.11	580.91	580.81	
11	579.5	580.41	580.65	581.08	580.84	580.78	
12	579.7	580.34	580.65	581.11	581.11	581.04	
13	579.9	580.51	580.78	581.11	581.31	581.11	
14	579.4	580.54	580.75	581.04	581.01	580.88	
15	579.8	580.38	580.81	581.04	581.04	580.81	During 1899, the daily means are from tri-daily staff gage readings.
16	579.9	580.51	581.05	581.18	581.01	580.61	
17	579.8	580.28	580.85	581.18	580.98	580.78	
18	579.8	580.48	580.78	581.16	580.91	580.76	
19	579.9	580.68	580.88	581.01	580.91	581.01	
20	580.0	580.61	580.95	581.08	580.94	580.74	
21	579.9	580.51	580.91	581.11	580.94	580.81	
22	580.0	580.51	580.75	581.14	581.21	580.81	
23	580.1	580.48	580.91	580.81	580.88	580.84	
24	579.9	580.44	580.81	580.98	580.94	580.78	
25	580.1	580.41	580.95	581.04	581.04	580.71	
26	580.1	580.31	580.88	581.01	580.84	580.74	
27	579.9	580.48	580.88	581.21	580.84	580.64	
28	579.8	580.41	581.01	581.08	580.91	580.41	
29	580.1	580.44	580.91	581.11	580.81	580.81	
30	580.0	580.71	581.05	581.41	580.81	580.74	
31	.....	580.58	.....	581.11	580.84	.....	
Mean	579.85	580.39	580.79	581.03	580.99	580.70	

Sheet 8—Cont'd

Day	1899 Oct.	1899 Nov.					REMARKS.
1	580.64	580.66					
2	580.31	580.36					
3	580.94	580.81					
4	580.51	580.41					
5	580.48	580.41					
6	580.44	580.31					
7	580.33	580.31					
8	580.31	580.31					
9	580.94	580.33					
10	580.14	580.34					
11	580.34	580.34					
12	580.31	580.34					
13	580.21	580.18					
14	580.61	580.18					
15	580.81	580.21					
16	580.11	580.14					
17	580.66	579.71					
18	580.34	580.21					
19	580.51	580.26					
20	580.46	580.11					
21	580.21	580.04					
22	579.66	580.24					
23	580.14	580.21					
24	580.31	580.21					
25	580.24	580.24					
26	580.56	580.21					
27	580.48	580.14					
28	580.71	580.11					
29	580.61	580.01					
30	580.51	580.01					
31	580.34						
Mean	580.33	580.24					

Sheet 1
(19 Sheets)

WILLIAMS EXHIBIT 29.

DAILY MEAN ELEVATIONS OF WATER SURFACE. AT AMHERSTBURG, ONT.

From tri-daily staff gage readings at Waterworks Dock. In terms of the U. S. Lake Survey, adjusted levels of 1903.

1898

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	573.09	572.97	572.65	572.40	572.07	571.52
2	573.00	572.90	572.60	572.55	571.67	571.58
3	572.96	572.87	572.65	572.34	571.94	572.00
4	572.94	572.86	572.36	572.35	572.13	572.90
5	573.22	572.77	572.45	572.20	572.00	570.73
6	573.16	572.80	572.26	572.53	570.87	571.77
7	572.99	572.77	571.79	572.46	571.97	571.45
8	572.87	572.76	572.34	572.33	571.41	571.62
9	573.27	572.85	572.40	572.32	572.69	571.52
10	572.87	572.72	572.63	572.59	572.77	570.80
11	573.22	572.81	572.56	572.09	572.03	571.63
12	573.22	572.73	572.55	572.16	572.13	572.00
13	573.10	572.82	572.52	572.42	572.07	571.90
14	572.95	572.93	572.44	572.05	571.89	571.72
15	572.90	572.68	572.49	571.79	571.68	572.61
16	573.08	572.69	572.41	572.42	572.20	572.74
17	573.06	572.65	572.42	573.09	572.18	572.47
18	572.88	573.11	572.02	572.57	572.04	572.25
19	572.77	572.86	572.10	571.89	571.74	572.76
20	572.76	572.78	572.36	572.42	572.17	572.15
21	573.12	572.74	572.59	572.15	572.12	572.02
22	572.87	572.70	572.65	571.18	571.64	572.34
23	572.90	572.70	571.91	571.72	571.65	571.34
24	572.95	572.67	572.29	572.20	571.52	571.70
25	572.70	572.46	572.28	572.35	572.03	572.22
26	573.04	572.76	572.13	571.82	571.76	572.09
27	572.91	572.85	572.39	571.92	571.98	570.93
28	572.60	572.87	572.50	572.33	572.23	572.17
29	572.88	572.54	572.43	572.22	572.06	572.11
30	572.77	572.67	572.30	571.72	571.46	571.97
31	573.07	572.62	.....	571.74	.....	572.17
Mean	572.97	572.77	572.38	572.19	571.94	571.91

Sheet 2.
(19 Sheets)

WILLIAMS EXHIBIT 29.

DAILY MEAN ELEVATIONS OF WATER SURFACE AT AMHERSTBURG, ONT.

From tri-daily staff gage readings at Waterworks Dock.
In terms of the U. S. Lake Survey adjusted levels of 1903.

1899

Day	Jan.	Feb.	Mar.	April	May
1	572.29	572.01	572.00	571.66	572.57
2	572.25	571.97	571.94	571.85	572.60
3	572.17	572.06	571.94	572.15	573.10
4	572.60	571.78	571.83	572.26	572.84
5	572.18	571.92	570.66	572.27	572.71
6	572.45	571.92	571.83	572.45	572.74
7	570.62	571.90	571.86	572.38	572.87
8	571.67	571.70	571.92	572.13	572.64
9	572.38	No record	571.83	572.11	572.73
10	572.46	571.79	572.22	572.42	572.75
11	572.62	571.83	571.92	572.57	572.49
12	572.40	571.75	571.33	572.33	572.65
13	572.33	571.73	571.87	572.51	572.21
14	571.77	571.78	572.47	572.18	572.31
15	572.06	571.75	571.46	572.38	572.72
16	572.13	571.74	572.05	572.33	572.72
17	572.04	571.68	572.51	572.55	572.93
18	572.09	571.73	572.07	572.65	572.36
19	572.14	571.76	571.27	572.48	572.55
20	572.20	571.88	571.47	572.67	572.73
21	571.93	571.87	573.09	572.77	572.76
22	572.13	571.72	572.25	572.57	572.85
23	572.30	571.80	571.04	572.77	572.81
24	572.01	571.80	571.88	572.65	572.88
25	571.91	571.97	572.68	572.60	572.84
26	571.54	571.83	572.30	572.57	572.86
27	571.74	571.19	572.39	572.69	572.76
28	571.89	571.61	572.12	572.59	572.96
29	571.88	.....	570.87	572.60	572.88
30	571.63	.....	572.30	572.63	572.83
31	571.98	.....	572.18	.....	572.94
Mean	572.06	571.80	571.91	572.43	572.74

Sheet 3
(19 Sheets).

WILLIAMS EXHIBIT 29.

DAILY MEAN ELEVATIONS OF WATER SURFACE AT AMHERSTBURG, ONT.

From records of self-registering gage.
In terms of the U. S. Lake Survey adjusted levels of 1903.

1899

Day	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	572.76	572.74	572.76	572.46	572.03	571.88	571.23
2	572.81	572.70	572.51	572.54	572.30	572.47	571.31
3	573.00	572.79	572.81	572.37	572.04	572.30	571.72
4	572.83	572.78	572.61	572.67	572.00	570.96	571.48
5	572.81	572.76	572.80	572.23	571.99	571.67	570.73
6	572.87	572.77	572.79	572.62	571.91	571.83	571.19
7	572.81	572.93	572.66	572.39	572.20	571.87	571.34
8	572.75	572.32	572.76	572.41	572.10	571.86	571.62
9	572.88	572.53	572.84	572.33	571.88	571.68	571.82
10	573.06	572.82	572.51	572.43	571.94	571.84	571.74
11	573.07	572.78	572.67	572.07	571.90	571.79	571.96
12	572.87	572.70	572.40	571.84	571.93	571.83	570.93
13	572.86	572.89	572.62	571.97	571.97	571.91	571.14
14	572.78	572.82	572.88	572.22	571.90	572.08	572.01
15	572.47	572.85	572.87	572.31	572.11	571.67	571.38
16	572.62	572.72	572.64	572.26	571.98	572.04	571.89
17	572.80	572.68	572.58	572.14	571.87	572.04	571.76
18	572.78	572.67	572.51	572.07	571.90	571.84	571.82
19	572.91	572.82	572.50	572.11	571.97	571.72	571.32
20	572.69	572.82	572.48	572.05	572.08	571.96	571.45
21	572.85	572.73	572.19	571.88	572.20	571.91	571.46
22	572.94	572.99	572.29	571.99	572.05	571.90	571.78
23	572.69	573.02	572.53	572.40	571.79	572.27	571.85
24	572.78	572.98	572.50	572.01	571.89	571.86	570.74
25	572.77	572.76	572.37	571.83	571.87	571.81	570.79
26	572.81	572.76	572.53	571.93	571.83	571.78	571.15
27	572.82	572.67	572.51	571.91	571.95	571.78	571.28
28	572.77	572.85	572.69	571.64	571.88	571.57	571.32
29	572.61	572.50	572.62	571.71	571.70	571.68	571.40
30	572.83	572.60	572.49	571.53	572.06	571.79	571.59
31	.....	572.83	572.42	.....	572.19	.....	.....
Mean	572.81	572.76	572.59	572.14	571.98	571.86	571.44

Note:—The self-registering gage is located opposite the foot of Bois Blanc Island. The approximate fall from the Waterworks Dock staff gage is .14 foot.

Sheet 4
(19 Sheets)

WILLIAMS EXHIBIT 29

DAILY MEAN ELEVATIONS OF WATER SURFACE AT AMHERSTBURG, ONT.

From records of self-registering gage.

In terms of the U. S. Lake Survey, adjusted levels of 1903.

1900

Day	June	July
1	572.78	572.60
2	572.33	572.86
3	572.68	572.50
4	572.75	572.54
5	572.74	572.61
6	572.75	572.49
7	572.71	572.60
8	572.64	571.85
9	572.83	572.31
10	572.86	572.67
11	572.70	572.33
12	572.87	572.48
13	572.78	572.47
14	572.72	572.59
15	572.87	572.59
16	572.90	572.53
17	572.70	572.44
18	572.90	572.64
19	572.74	572.73
20	572.74	572.56
21	572.71	572.47
22	573.07	572.72
23	572.94	572.63
24	572.78	572.68
25	572.75	572.67
26	572.72	572.79
27	572.59	572.75
28	572.55	572.75
29	572.31	572.62
30	572.48	572.64
31	.....	572.59
Mean	572.73	572.57

Note:—The self-registering gage is located opposite the foot of Bois Blanc Island. The approximate fall from the Waterworks Dock staff gage is .14 foot.

Sheet 5
(19 Sheets)

WILLIAMS EXHIBIT 29

ELEVATIONS OF WATER SURFACE OF DETROIT RIVER

From record of self-registering gage at

AMHERSTBURG, ONT.

In terms of U. S. Lake Survey adjusted levels of 1903:

1909

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	.....	.....	.....	572.11	572.07	572.14
2	.....	.....	.....	572.33	571.59	572.37
3	.....	.....	.....	572.41	571.70	572.01
4	.....	.....	.....	572.50	571.58	572.04
5	.....	.....	.....	572.51	571.91	571.90
6	.....	.....	.....	572.37	572.22	571.07
7	.....	.....	.....	572.36	572.05	571.11
8	.....	.....	.....	572.40	571.95	571.09
9	.....	.....	.....	572.42	572.27	571.19
10	.....	.....	.....	572.38	572.04	571.67
11	.....	.....	.....	572.07	571.96	572.00
12	.....	.....	.....	570.93	571.95	572.78
13	.....	.....	.....	571.32	572.19	571.97
14	.....	.....	.....	571.42	571.99	570.75
15	.....	.....	.....	571.59	571.82	571.12
16	.....	.....	.....	571.21	572.08	571.71
17	.....	.....	.....	571.89	569.96	571.09
18	.....	.....	.....	571.95	571.54	571.18
19	.....	.....	.....	572.05	571.61	571.96a
20	.....	.....	.....	572.23	571.60	572.07a
21	.....	.....	.....	571.76	571.82	571.98
22	.....	.....	.....	571.52	571.82	571.88
23	.....	.....	.....	572.07	571.85	572.10
24	.....	.....	.....	571.91	572.37	572.25
25	.....	.....	.....	571.95	571.90	572.36
26	.....	.....	.....	571.68	572.03	572.32a
27	.....	.....	.....	571.38	572.03	c
28	.....	.....	.....	571.68	571.90	c
29	.....	.....	.....	571.97	572.20	c
30	.....	.....	.....	571.98	572.14	c
31	.....	.....	.....	571.87	.....	c
Mean	.....	.....	.....	571.94	571.87	571.77

Note:—a = Mean of partial day only.

b =

c = No record, gage out of order.

This gage is maintained and operated under direction of U. S. Engineer Office, Detroit District.

Sheet 6.
(19 Sheets)

WILLIAMS EXHIBIT 29.

ELEVATIONS OF WATER SURFACE OF DETROIT RIVER

from record of self-registering gage at

AMHERSTBURG, ONT.

In terms of U. S. Lake Survey adjusted levels of 1903.

1910

Day	Jan.	Feb.	Mar.	April	May	June
1	a	571.69	571.47	572.11	572.81	572.45
2	a	571.54	571.49	572.18	572.71	572.88
3	a	571.55	571.70	572.27	572.69	572.80
4	a	571.18	571.67	572.24	572.84	573.14
5	a	571.39	571.65	572.26	572.81	573.00
6	a	571.36	571.57	571.93	572.83	572.81
7	571.37b	571.41	571.20	571.77	572.96	572.76
8	571.64	571.45	571.54	572.17	572.94	572.86
9	571.50	571.42	571.71	572.12	572.72	573.00
10	571.64	571.38	571.81	572.16	572.77	573.14
11	571.64	571.61	571.88	572.29	572.84	572.94
12	571.65	571.54	571.73	572.25	572.67	572.84
13	572.15	571.28	571.22	572.25	572.70	572.96
14	572.07	571.52	571.28	572.24	572.75	572.91
15	571.72	571.64	571.63	572.24	572.91	572.91
16	571.56	571.45	571.71	572.48	572.89	572.94
17	571.67	571.66	571.85	572.24	572.89	572.88
18	571.14	571.52	571.96	572.46	572.29	572.85
19	571.32	571.47	571.77	571.97	572.84	572.96
20	571.53	571.53	571.75	572.03	572.86	572.96
21	571.48	571.52	571.83	572.33	572.84	572.92
22	570.92	571.64	571.78	572.65	572.88	572.89
23	571.46	571.37	571.98	572.41	572.76	572.85
24	571.59	571.54	571.85	572.40	572.89	573.14
25	571.72	571.58	571.80	572.37	572.80	573.03
26	571.73	571.61	572.11	572.66	572.67	572.93
27	571.29	571.60	572.25	572.57	572.77	572.82
28	571.69	571.69	572.03	572.95	572.91	572.78
29	571.58	.....	572.12	572.73	572.73	572.83
30	571.70	.....	572.16	572.46	572.15	572.86
31	571.61	.....	571.92	.....	572.41	.....
Mean	571.58	571.50	571.76	572.31	572.76	572.90

Note:—a = no record, gage out of order.
b = mean of partial day only.

This gage is maintained and operated under direction of U. S. Engineer Office, Detroit District.

Sheet 7.
(19 Sheets)

WILLIAMS EXHIBIT 29.

ELEVATIONS OF WATER SURFACE OF DETROIT RIVER

from record of self-registering gage at

AMHERSTBURG, ONT.

In terms of U. S. Lake Survey adjusted levels of 1903.

1910

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	572.80	572.73	572.43	571.55	571.93	571.30
2	572.83	572.67	572.54	572.26	571.35	571.43
3	572.82	572.73	572.24	572.23	572.07	571.70
4	573.09	572.21	572.51	572.11	571.95	571.89
5	573.08	572.18	572.39	572.19	571.62	572.22
6	572.89	572.54	572.15	571.93	571.10	572.01
7	572.85	572.73	572.40	572.43	571.68	571.10
8	572.89	572.58	572.38	572.31	571.44	571.11
9	572.77	572.53	572.20	571.97	571.86	571.61
10	572.67	572.68	572.43	572.25	571.06	572.01
11	572.81	572.55	572.40	571.99	571.68	571.59
12	572.79	572.68	572.26	572.37	571.95	571.61
13	572.72	572.57	572.29	572.62	571.16	571.40
14	572.92	572.57	572.35	572.10	571.60	570.60
15	572.83	572.55	572.28	572.10	571.31	571.07
16	572.90	572.62	572.35	572.08	571.29	571.73
17	572.96	572.60	572.22	572.33	571.52	571.89
18	572.92	572.52	572.11	572.20	571.31	571.90
19	572.82	572.55	572.57	572.19	571.74	571.10
20	572.76	572.57	572.13	572.21	571.90	571.14
21	572.65	572.60	572.28	572.33	571.43	571.42
22	572.57	572.43	572.58	571.13	571.71	571.75
23	572.74	572.46	572.26	571.94	571.66	571.81
24	572.60	572.52	572.31	571.93	571.68	571.58
25	572.59	572.04	572.12	571.94	571.46	571.68
26	572.74	572.31	572.43	572.00	571.71	571.29
27	572.70	572.38	571.82	571.17	571.44	571.26
28	572.72	572.50	572.18	571.24	571.44	571.53
29	572.68	572.79	572.28	571.69	570.70	571.54
30	572.64	572.46	572.09	571.68	570.95	571.42
31	572.67	572.36	.....	571.81	.....	571.56
Mean	572.80	572.52	572.30	572.01	571.52	571.52

Note:—This gage is maintained and operated under direction of U. S. Engineer Office, Detroit District.

Sheet 8
(19 Sheets)

WILLIAMS EXHIBIT 29

DAILY MEAN ELEVATIONS OF WATER SURFACE OF LAKE ERIE

from tri-daily staff-gage readings at

CLEVELAND, O.

In terms of the Lake Survey adjusted levels of 1903.

1898

Day	Oct.
1	571.96
2	571.91
3	571.94
4	572.02
5	572.05
6	572.10
7	572.03
8	571.97
9	571.87
10	571.95
11	571.59
12	571.94
13	571.94
14	571.64
15	571.84
16	571.76
17	572.08
18	572.00
19	571.61
20	571.75
21	571.75
22	571.44
23	571.49
24	571.55
25	571.63
26	571.81
27	571.71
28	571.75
29	571.71
30	571.54
31	571.94
Mean	571.81

WILLIAMS EXHIBIT 29 Sheet 9 (19 Sheets)

DAILY MEAN ELEVATIONS OF WATER SURFACE OF LAKE ERIE,

from tri-daily staff gage readings at

CLEVELAND, O.

In terms of Lake Survey adjusted levels of 1903.

	1899 June	1900 July
1	572.56	572.38
2	572.61	572.44
3	572.67	572.18
4	572.57	572.27
5	572.58	572.44
6	572.58	572.29
7	572.58	572.34
8	572.60	572.54
9	572.63	572.48
10	572.64	572.39
11	572.56	572.36
12	572.55	572.17
13	572.50	572.31
14	572.54	572.31
15	572.67	572.30
16	572.62	572.24
17	572.55	572.07
18	572.49	572.38
19	572.59	572.30
20	572.49	572.32
21	572.59	572.30
22	572.52	572.36
23	572.46	572.30
24	572.45	572.49
25	572.51	572.59
26	572.49	572.50
27	572.42	572.37
28	572.53	572.41
29	572.60	572.26
30	572.52	572.28
31	.....	572.28
Mean	572.56	572.34

Sheet 10.
(19 Sheets)

WILLIAMS EXHIBIT 29.

Memorandum of daily water levels at Cleveland Harbor, Ohio, each being a mean of readings taken at 7:00 A. M., 1:00 P. M. and 7:00 P. M. Elevations are referred to Mean Lake Level 1860-75, which is 572.77 ft. above Mean Tide at New York.

All the following readings are below this datum, unless marked +, when they are above.

Day	1898 July	1898 Aug.	1898 Sept.	1898 Oct.	1898 Nov.	1898 Dec.	1899 Jan.	1899 Feb.	1899 Mar.	1899 Apr.	1899 May	1899 June
1	.04	.18	.55	.81	1.39	1.56	1.03	1.16	1.20	.95	.52	.20
2	.05	.21	.57	.86	1.31	1.47	1.44	1.12	1.19	.81	.46	.15
3	.06	.41	.58	.83	1.20	1.13	1.31	1.08	1.01	.75	.08	.09
4	+ .02	.31	.91	.75	1.20	.62	1.24	1.27	.94	.72	.32	.20
5	+ .04	.35	.85	.72	1.38	.58	1.14	1.18	1.61	.72	.44	.19
6	.00	.30	.71	.67	1.12	1.20	.84	1.19	.76	.69	.45	.19
7	.05	.40	.62	.74	1.29	1.42	.95	1.23	.84	.61	.41	.19
8	.14	.31	.79	.80	1.45	1.32	1.21	1.36	1.13	.70	.47	.16
9	.27	.24	.62	.90	.74	1.18	.83	1.41	1.10	.74	.42	.14
10	.18	.27	.49	.82	.41	1.81	.89	1.30	.91	.67	.42	.13
11	+ .01	.26	.70	1.17	.73	1.53	.84	1.27	1.16	.73	.40	.20
12	.12	.33	.68	.83	.98	.98	1.06	1.28	1.21	.73	.47	.22
13	.17	.28	.77	.83	1.10	1.05	1.11	1.34	1.08	.64	.32	.27
14	.26	.31	.79	1.13	.97	1.74	1.19	1.34	.77	.75	.34	.22
15	.24	.53	.70	.93	1.27	1.46	1.04	1.35	1.35	.78	.31	.09
16	.24	.52	.75	1.01	1.00	1.47	.97	1.35	1.13	.68	.20	.15
17	.29	.17	.81	.69	1.00	1.52	.94	1.40	.96	.62	.09	.22
18	.30	.28	.93	.77	1.07	1.37	.81	1.41	.90	.60	.30	.28
19	.25	.31	.79	1.16	.93	1.10	.94	1.44	.86	.58	.32	.18
20	.30	.43	.78	1.04	.95	1.32	1.03	1.42	.89	.56	.29	.28
21	.22	.45	.74	1.02	1.02	1.28	1.22	1.36	.70	.48	.29	.18
22	.15	.45	.92	1.34	1.18	1.07	.98	1.39	1.02	.46	.25	.24
23	.22	.48	.89	1.28	1.17	1.53	.90	1.28	1.05	.40	.31	.31
24	.22	.45	.82	1.22	.95	1.00	.92	1.32	.84	.53	.31	.32
25	.41	.56	.89	1.14	1.14	1.04	1.07	1.20	.60	.48	.38	.25
26	.17	.37	.90	.96	.91	1.22	1.13	1.47	.88	.54	.36	.28
27	.24	.41	.85	1.06	.98	1.31	1.07	1.50	.62	.52	.51	.35
28	.39	.51	.83	1.02	1.15	1.12	1.21	1.48	.71	.60	.15	.24
29	.48	.60	.88	1.06	1.07	1.29	1.16	.....	.81	.48	.33	.17
30	.23	.51	.88	1.23	1.29	1.08	1.26	.....	.75	.20	.21	.24
31	.11	.59	.....	.83	.....	.76	1.12	.....	.81	.....	.21	.....

Sheet 11.
(19 Sheets)

WILLIAMS EXHIBIT 29.

Day	1899 July	1899 Aug.	1899 Sept.	1899 Oct.	1899 Nov.	1899 Dec.	1900 June	1900 July
1	.29	.44	.71	1.13	1.01	1.56	.34	.39
2	.41	.36	.76	1.12	.93	1.58	.24	.33
3	.30	.28	.80	1.14	.80	1.13	.34	.59
4	.28	.38	.57	1.24	1.38	1.20	.25	.50
5	.27	.29	1.15	1.10	1.09	1.96	.30	.33
6	.23	.39	.69	1.15	1.15	1.29	.29	.48
7	.26	.45	.86	1.15	1.20	1.70	.22	.43
8	.10	.48	.93	1.13	1.17	1.36	.23	.23
9	.35	.55	.77	1.30	1.31	1.21	.18	.29
10	.32	.53	.80	1.27	1.18	1.48	.33	.39
11	.36	.52	.81	1.24	.98	1.42	.23	.41
12	.33	.58	.94	1.18	1.09	1.30	.23	.60
13	.26	.46	.86	1.17	1.17	1.44	.33	.46
14	.34	.45	.86	1.19	1.49	1.07	.13	.46
15	.35	.38	.95	1.12	1.31	1.30	.23	.46
16	.26	.57	1.02	1.21	1.04	1.28	.26	.53
17	.26	.58	1.00	1.17	1.17	1.59	.28	.69
18	.35	.58	1.03	1.11	1.25	1.45	.21	.38
19	.26	.65	.74	1.05	1.20	1.31	.30	.47
20	.21	.67	.83	1.07	1.18	1.21	.31	.45
21	.31	.81	1.11	1.08	1.20	1.53	.36	.46
22	.21	.73	1.15	1.27	1.17	1.21	.24	.41
23	.21	.64	.91	1.26	.74	1.22	.24	.47
24	.24	.65	1.13	1.23	1.12	1.07	.30	.28
25	.38	.63	.85	1.22	1.12	1.32	.36	.17
26	.30	.76	.67	1.30	1.20	1.27	.41	.27
27	.26	.67	1.20	1.17	1.26	1.30	.45	.40
28	.25	.55	1.30	1.11	1.30	1.50	.38	.35
29	.44	.69	1.11	1.13	1.36	1.16	.38	.51
30	.40	.75	1.09	1.08	1.35	1.33	.49	.49
31	.35	.70	.....	.88	.....	1.98	.....	.48

WILLIAMS EXHIBIT 29 Sheet 12 (19 Sheets)

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

From Record of Self-registering Gage at

CLEVELAND, OHIO

In Terms of U. S. Lake Survey Adjusted Levels of 1903

1909

Day	Oct.	Nov.	Dec.
1	571.86	571.58	571.74
2	572.08	571.37	571.84
3	572.06	571.50	571.76
4	572.08	571.61	571.70
5	572.08	571.57	571.57
6	572.03	571.68	571.32
7	572.00	571.57	571.24
8	572.01	571.72	571.05
9	572.03	571.80	571.11
10	571.92	571.58	571.34
11	571.78	571.54	571.53
12	571.24	571.62	571.75
13	571.44	571.74	571.52
14	571.47	571.57	570.90
15	571.72	571.60	571.28
16	571.67	571.60	571.36
17	571.70	571.24	571.15
18	571.83	571.57	571.13
19	571.75	571.22	571.33
20	571.76	571.19	571.24
21	571.54	571.48	571.30
22	571.60	571.76	571.40
23	572.07	571.89	571.41
24	571.88	571.94	571.40
25	571.50	571.68	571.66
26	571.44	571.69	571.50
27	571.64	571.66	571.28
28	571.72	571.73	571.27
29	571.64	571.88	571.50
30	571.55	571.72	571.15
31	571.52	.....	571.33
Mean	571.76	571.61	571.39

WILLIAMS EXHIBIT 29 Sheet 13 (19 sheets)

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

From Record of Self-registering Gage at

CLEVELAND, OHIO

In Terms of U. S. Lake Survey Adjusted Levels of 1903

1910

Day	Jan.	Feb.	Mar.	Apr.	May	June
1	571.25	571.22	571.27	571.86	572.45	572.57
2	571.38	571.23	571.28	571.92	572.52	572.60
3	571.27	571.39	571.35	571.93	572.65	572.71
4	571.51	571.12	571.39	571.91	572.65	572.70
5	571.23	571.22	571.45	571.94	572.61	572.67
6	571.37	571.23	571.45	571.92	572.56	572.62
7	571.13	571.14	571.42	571.99	572.60	572.59
8	571.16	571.15	571.55	571.91	572.61	572.58
9	571.29	571.19	571.61	571.92	572.56	572.66
10	571.26	571.21	571.61	571.94	572.53	572.72
11	571.22	571.19	571.72	572.07	572.61	572.75
12	571.26	571.21	571.73	571.98	572.57	572.59
13	571.59	571.08	571.72	571.97	572.65	572.63
14	571.72	571.12	571.86	571.95	572.60	572.62
15	571.29	571.13	571.68	571.99	572.57	572.63
16	571.14	571.14	571.65	572.02	572.57	572.64
17	571.17	571.30	571.75	572.00	572.42	572.62
18	570.93	571.14	571.77	572.06	572.44	572.61
19	571.12	571.09	571.66	571.94	572.59	572.65
20	571.14	571.13	571.69	572.30	572.54	572.62
21	571.35	571.15	571.76	572.26	572.59	572.61
22	571.17	571.18	571.71	572.21	572.60	572.59
23	571.05	571.05	571.86	572.22	572.50	572.58
24	571.25	571.12	571.78	572.26	572.61	a572.82
25	571.25	571.11	571.78	572.32	572.57	a572.65
26	571.21	571.01	571.85	572.23	572.63	a572.53
27	571.13	571.08	571.90	572.35	572.58	a572.46
28	571.28	571.21	571.81	572.45	572.57	a572.48
29	571.23	.....	571.86	572.35	572.52	572.42
30	571.24	.....	571.85	572.32	572.67	572.44
31	571.21	.....	571.81	.....	572.63	.....
Mean	571.25	571.16	571.66	572.08	572.57	572.61

Note: a—Gage not in commission account of repairs; values from tri-daily staff gage readings of U. S. Engineer Office gage at Cleveland.

Note: b—Mean of partial day only, the remaining hours of the day being supplied from mean stage range.

Sheet 14.
(19 Sheets)

WILLIAMS EXHIBIT 29.

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

From Record of Self-Registering Gage at

CLEVELAND, OHIO.

In Terms of U. S. Lake Survey Adjusted Levels of 1903.

1910

Day	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	572.38	572.37	572.19	571.79	571.39	571.79
2	572.40	572.40	572.14	571.86	571.54	571.57
3	572.40	572.37	572.05	571.74	571.78	571.42
4	572.56	572.35	572.20	571.64	571.76	571.58
5	572.41	572.27	572.08	571.78	571.60	571.86
6	572.36	572.28	572.03	572.28	571.62	571.83
7	572.36	572.28	572.10	572.13	571.41	571.07
8	572.37	572.23	572.12	572.03a	571.54	571.25
9	572.31	572.18	572.21	572.07	571.27	571.40
10	572.31a	572.26	572.10	571.97	571.41	571.50
11	572.33a	572.26	572.07	571.79	571.45	571.55
12	572.30	572.29	572.02	572.07	571.64	571.57
13	572.38	572.28b	572.13	572.00a	571.45	571.20
14	572.49	572.29b	572.11	571.88	571.48	571.00
15	572.51	572.24	571.98	571.90	571.54	571.37
16	572.58	572.25	572.01	571.89	571.44	571.39
17	572.64	572.21	571.96b	571.98	571.33	571.15
18	572.54	572.24	571.93	571.94b	571.31	571.10
19	572.43	572.29	572.06	571.93b	571.40	570.99
20	572.25a	572.23	571.93	572.05	571.42b	571.23
21	572.28a	572.17	571.99	572.09	571.33	571.41
22	572.29	572.08	572.05	571.56	571.43	571.17
23	572.33a	572.09	571.91	571.92	571.16	571.15
24	572.30a	572.06	571.90	571.64	571.16	571.16
25	572.41a	572.02	571.89	571.93	571.39b	571.19
26	572.43	572.12	571.90a	571.85	c	571.01
27	572.33	572.04	571.86a	571.74	c	570.99
28	572.42	572.11	571.89	571.85	571.58	571.20
29	572.37	572.26	571.90	571.94	571.49	571.26
30	572.47	572.08	571.79	571.33	571.50	571.27
31	572.40	572.11	.....	571.64	.....	571.07
Mean	572.40	572.22	572.02	571.88	571.46	571.34

Note:—a=Mean of partial day only, the remaining hours of the day being supplied from mean stage range.

b=Mean of partial day only, range not well defined, etc.

c=No record, repairs being made to gage.

Sheet 15.
(19 Sheets)

WILLIAMS EXHIBIT 29.

BUFFALO HARBOR, N. Y.

Record of Daily Mean Water Level, U. S. Engineer Self-Registering Gauge in U. S. Light House Slip, Inner End U. S. South Pier.
Zero of Gauge at Elevation 573.15 feet above mean tide of N. Y. Adjusted U. S. Lake Survey Levels of 1903.
Feet and tenths above or below zero.

	1898						1899	
Date	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
1	−0.3	−0.6	−0.9	−1.4	−1.0	−0.4	−1.7	−1.5
2	−0.3	−0.6	−0.8	−1.3	−0.6	−0.8	−1.0	−1.5
3	−0.3	−0.4	−0.8	−1.3	−1.2	−1.6	−1.2	−1.6
4	−0.3	−0.3	−0.5	−1.3	−1.3	−2.8	−1.0	−1.5
5	−0.8	−0.4	−0.6	−1.1	−0.8	−0.6	−0.7	−1.6
6	−0.6	−0.6	−0.5	−1.5	+1.0	−0.4	−1.4	−1.6
7	−0.5	−0.5	−0.1	−1.4	−0.6	00.0	+1.6	−1.6
8	−0.4	−0.4	−0.5	−1.2	−0.3	−0.5	+0.5	−1.2
9	−0.4	−0.7	−0.9	−1.3	−2.0	−0.7	.....	−1.3
10	−0.5	−0.7	−1.3	−1.4	−1.9	+0.4	.....	−1.6
11	−0.9	−0.7	−1.1	−0.4	−0.9	−0.3	−2.0	−1.6
12	−0.9	−0.5	−1.4	−1.0	−1.0	−2.0	−1.7	−1.6
13	−0.8	−0.7	−1.2	−1.4	−1.0	−1.6	−1.7	−1.6
14	−0.7	−0.7	−1.1	−0.9	−1.0	−0.4	−1.0	−1.6
15	−0.6	−0.5	−1.0	−0.9	−0.6	.....	−0.9	−1.7
16	−0.6	−0.3	−1.0	−1.4	−1.4	.....	−1.5	−1.7
17	−0.5	−0.1	−1.1	−2.0	−1.5	.....	−1.4	−1.7
18	−0.2	.....	−0.6	−1.5	−1.4	.....	−1.6	−1.7
19	.....	.....	−0.9	−1.0	−1.0	.....	−1.4	−1.7
20	.....	.....	−1.2	−1.5	−1.2	−1.0	−1.3	−1.7
21	−0.2	−0.6	−1.4	−1.2	−1.6	−1.7	−0.9	−1.8
22	−0.8	−0.6	−1.2	+0.2	−0.6	−1.9	−1.1	−1.5
23	−0.8	−0.5	−0.8	+0.2	−0.8	−0.7	−1.6	−1.6
24	.....	−0.5	−1.2	−1.0	−1.2	−0.6	−1.3	−1.6
25	.....	−0.4	−1.0	−1.2	−1.2	−1.8	−1.2	−1.8
26	.....	−0.8	−1.0	0.0	−1.7	−1.0	−0.2	−1.8
27	−0.7	−1.0	−1.2	−1.4	−1.5	0.0	−1.0	−0.8
28	−0.5	−1.0	−1.3	−2.3	−1.6	.....	−1.3	−1.3
29	−0.4	−0.6	−1.3	−1.2	−1.5	−1.0	−1.3	.....
30	−0.6	−0.9	−1.3	−0.9	−0.8	−1.4	−1.0	.....
31	−0.8	−0.8	.....	−1.2	.....	−1.8	−1.5	.....

Blank spaces—No record, gauge out of order.

WILLIAMS EXHIBIT 29.
BUFFALO HARBOR, N. Y.

Sheet 16.
(19 Sheets)

Record of Daily Mean Water Level, U. S. Engineer Self-Registering Gauge in U. S. Light House Slip, inner end U. S. South Pier. Zero of Gauge at elevation 573.15 feet above mean tide at N. Y. Adjusted U. S. Lake Survey Levels of 1903. Feet and tenths above or below zero.

Date	1899										1900											
	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-1.6	-0.7	-1.2	-0.6	-0.6	-0.9	-1.2	-1.6	-1.8	-1.0	-1.0	-0.9	.....	-1.0	-1.1	-0.9	-0.7	-0.9	-1.0	-1.6	-0.6	-1.2
2	-1.7	-1.1	-1.3	-0.7	-0.5	-0.7	-1.2	-0.9	-2.3	-0.8	0.0	.....	.....	-1.2	-1.0	-0.5	-1.0	-0.7	-1.0	-1.4	-1.3	-1.5
3	-1.7	-1.2	-1.6	-0.8	-0.6	-1.0	-1.0	-1.7	-1.2	-1.7	-1.5	.....	.....	-1.0	-0.6	-0.5	-0.5	-0.9	-0.7	-1.4	-1.3	-1.6
4	-1.8	-1.3	-1.4	-0.8	-0.6	-1.0	-1.4	-1.6	-0.6	-1.5	-1.9	-2.0	-2.1	-1.0	-0.6	.....	-0.8	-0.8	-1.0	-1.2	-1.2	-1.6
5	-0.9	-1.3	-1.3	-0.7	-0.5	-1.0	-1.0	-1.7	-1.3	-0.1	-1.5	-1.7	-2.4	-0.8	-0.7	.....	-0.8	-0.9	-1.0	-1.1	-1.0	-0.8
6	-1.4	-1.3	-1.1	-0.6	-0.5	-0.9	-1.4	-1.7	-1.4	-1.0	-2.0	-1.7	-1.2	-0.8	-0.9	-0.7	-0.5	-0.8	-0.6	-1.2	-1.5	-1.2
7	-1.4	-1.4	-1.1	-0.6	-0.6	-1.0	-1.2	-2.0	-1.5	-0.8	-1.5	-1.9	-1.5	-1.0	-1.1	-0.6	-0.5	-0.7	-1.5	-1.1	-1.6	-1.5
8	-1.2	-0.9	-1.1	-0.5	-0.4	-1.0	-1.3	-1.9	-1.6	-1.6	-2.0	-1.8	-1.9	-1.0	-0.8	-0.5	0.0	-0.6	-1.3	-1.3	-1.3	-1.0
9	-1.3	-1.0	-1.0	-0.6	-0.5	-1.1	-1.3	-1.7	-1.2	-2.0	-2.0	-0.4	-1.8	-1.0	-0.8	-0.6	-0.4	-0.7	-1.2	-1.4	-1.0	-0.4
10	-1.6	-1.2	-1.1	-0.8	-0.7	-0.9	-1.3	-1.6	-1.5	-1.7	-1.8	-1.9	-1.7	-1.0	-0.7	-0.8	-0.7	-0.6	-1.3	-1.4	-1.1	-1.2
11	-1.4	-1.3	-0.8	-0.8	-0.8	-1.0	-1.0	-1.6	-1.9	-1.8	-2.4	-1.9	-2.0	-1.5	-0.8	-0.6	-0.5	-0.5	-1.0	-1.4	-1.4	-1.1
12	-0.8	-1.2	-1.0	-0.8	-0.7	-0.7	-0.8	-1.6	-1.6	+0.2	-1.6	-1.9	-1.8	-0.8	-0.8	-1.0	-0.4	-1.2	+1.3	-1.4	-0.2	-1.0
13	-1.2	-1.2	-0.8	-0.7	-0.8	-1.0	-1.1	-1.6	-1.6	-0.8	-1.8	-1.0	-1.7	-0.8	-0.6	-0.8	-0.5	-0.6	-1.0	-1.6	-1.1	-0.4
14	-2.0	-1.0	-0.9	-0.7	-0.8	-1.5	-1.3	-1.5	-0.9	-2.2	-1.7	-1.3	-1.7	-0.6	-0.6	-0.8	-0.8	-1.0	-1.4	-1.4	-0.7	-1.8
15	-1.0	-1.0	-1.0	-0.7	-0.7	-1.5	-1.4	-1.8	-1.2	-1.2	-2.0	-1.3	-2.0	-1.2	-0.6	-0.8	-0.8	-0.9	-1.6	-1.3	-0.9	-1.8
16	-1.3	-1.0	-1.1	-0.6	-0.5	-1.2	-1.3	-1.7	-1.8	-1.8	-1.8	-1.4	-1.8	-1.3	-1.0	-0.9	-0.7	-0.7	-0.3	-1.4	-1.5	-1.8
17	-1.8	-1.2	-1.4	-0.6	-0.6	-1.1	-1.3	-1.4	-0.6	-1.4	-2.2	-1.6	-1.0	-1.4	-0.7	-0.8	-0.8	-0.9	-0.8	-1.2	-1.5	-1.8
18	-1.6	-1.2	-0.8	-0.6	-0.4	-1.0	-1.3	-1.4	-1.4	-1.7	-1.8	-1.6	-1.9	-1.1	-0.8	-1.0	-0.8	-0.9	-1.4	-1.1	-1.4	-1.3
19	-1.1	-1.2	-0.6	-0.8	-0.7	-1.0	-1.6	-1.7	-1.3	-1.0	-1.8	-1.6	-1.8	-0.8	-0.8	-1.0	-0.9	-1.1	-1.6	-1.8	-1.6	-1.4
20	-0.7	-1.2	-0.8	-0.8	-0.7	-1.0	-1.3	-0.8	-1.6	-1.0	-1.8	-1.8	-1.3	-1.2	-0.4	-0.9	-0.8	-0.8	-0.8	-1.6	-1.7	-1.6
21	-1.7	-1.2	-0.9	-0.7	-0.5	-0.7	-0.9	-0.9	-1.8	-1.1	-1.4	-2.1	-1.7	-1.0	-0.5	-0.8	-0.5	-1.0	-1.0	-1.5	+0.5	-1.8
22	-1.4	-1.2	-1.0	-0.8	-1.0	-0.8	-1.1	-0.6	-1.7	-1.6	-1.6	-1.7	-1.8	-1.1	-0.4	-1.0	-0.9	-1.0	-1.2	-1.4	-1.5	-1.8
23	-0.1	-1.3	-1.0	-0.6	-1.0	-1.1	-0.7	-0.5	-2.3	-1.8	-1.5	-1.3	-1.5	-1.1	-0.6	-1.2	-1.0	-1.0	-1.3	-1.4	-1.3	-1.6
24	-0.9	-1.2	-1.0	-0.8	-1.0	-1.1	-1.1	-0.5	-1.7	-0.6	-2.0	-1.2	-1.4	-1.1	-0.7	-0.8	-1.0	-0.8	-1.5	-1.4	-2.4	-0.6
25	-1.5	-1.1	-1.0	-0.7	-0.8	-1.1	-1.1	-0.6	-1.7	-0.6	-1.2	.....	-1.7	-1.1	-0.7	-0.8	-0.9	-0.8	-1.4	-1.7	-3.0	-0.9
26	-1.2	-1.2	-1.0	-0.7	-0.7	-1.3	-1.5	-0.5	-1.6	-0.6	-0.6	.....	-1.4	-1.0	-0.8	-0.8	-0.8	-0.9	-1.2	-1.3	-2.4	-1.1
27	-1.4	-1.2	-1.0	-0.6	-0.6	-1.2	-0.8	-0.7	-1.6	-1.0	-1.2	.....	-1.0	-0.9	-0.7	-0.6	-0.9	-0.7	-1.4	-1.5	-1.6	-1.5
28	-1.1	-1.2	-0.8	-1.1	-0.7	-1.4	-0.6	-1.0	-1.2	-0.8	-0.6	.....	-1.1	-0.9	-0.7	-0.5	-0.8	-0.8	-1.6	-1.6	-1.3	-1.5
29	+0.4	-1.1	-0.7	-1.0	-0.6	-1.2	-0.3	-1.3	-1.3	-1.2	-1.0	.....	-1.3	-1.0	-0.9	-0.5	-0.7	-1.0	-1.3	-1.6	-1.2	-0.4
30	-1.1	-1.3	-0.5	-0.6	-0.6	-1.2	-0.9	-1.6	-1.4	-1.2	-0.9	.....	-1.4	-1.0	-0.8	-0.5	-0.7	-1.0	-1.3	-1.6	-1.2	-1.4
31	-1.3	.....	-0.9	.....	-0.6	-1.1	.....	-2.0	.....	-0.5	-1.0	.....	-1.0	.....	-0.7	.....	-0.5	-1.0	.....	-1.8	.....	-1.4

Sheet 10—Cont'd.

Date	1901												1902				
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.		
1	−1.4	−1.3	−2.4	−2.0	−2.0	−1.5	−1.2	−1.2	−1.6	−1.8	−1.3	−1.9	−1.6	−2.0	−1.7		
2	−1.3	−2.0	−2.5	−2.4	−1.8	−1.5	−1.1	−1.3	−1.5	−1.4	−2.0	−1.8	−0.6	−1.6	−2.0		
3	−1.8	−2.6	−2.4	−2.2	−1.8	−1.4	−1.2	−1.4	−1.4	−1.3	−2.1	−2.3	−0.9	−0.6	−1.9		
4	−1.4	−2.0	−2.4	−1.8	−1.8	−1.7	−1.3	−1.4	−1.3	−1.5	−1.4	−1.9	−1.0	−1.5	−2.2		
5	−1.8	−1.8	−2.3	−2.1	−1.9	−1.6	−1.2	−1.8	−1.3	−1.0	−1.8	−2.1	−1.0	−1.8	−2.4		
6	−1.8	−1.8	−2.3	−2.3	−2.2	−1.5	−0.9	−1.8	−1.3	−1.8	−1.9	−2.1	−1.8	−2.2	−2.0		
7	−1.5	−2.0	−2.6	−1.8	−2.2	−1.2	−0.8	−1.4	−1.3	−1.8	−1.2	−1.7	−2.1	−1.9	−2.0		
8	−1.6	−2.4	−2.6	−1.8	−2.1	−1.0	−1.3	−1.1	−1.9	−1.7	−1.6	−2.2	−1.9	−2.0	−2.1		
9	−2.0	−2.4	−2.7	−1.8	−2.1	−1.8	−1.3	−1.8	−1.7	−1.6	−1.6	−2.2	−2.0		−1.9		
10	−1.8	−2.0	−2.3	−2.0	−2.1	−1.7	−1.2	−1.0	−1.4	−1.6	−2.1	−0.6	−1.7		−2.1		
11	−1.8	−2.1	−1.7	−2.0	−1.7	−1.6	−1.6	−1.5	−1.2	−1.8	−2.5	−2.0	−1.0		−2.0		
12	−0.6	−1.8	−2.1	−2.1	−1.7	−1.7	−1.7	−1.6	−1.0	−1.8	−1.1	−2.0	−1.6		−1.9		
13	−1.6	−2.0	−3.0	−2.2	−1.7	−1.7	−1.6	−1.6	−1.0	−1.0	−1.5	−2.0	−1.6		−1.7		
14	−1.6	−2.0	−2.3	−2.1	−2.0	−1.6	−1.5	−1.6	−1.5	−1.6	−1.0	−1.5	−1.6	−2.0	−2.2		
15	−1.6	−2.0	−2.3	−2.0	−2.0	−1.5	−1.4	−1.4	−0.7	−1.2	−1.3	−1.2	−2.0	−2.0	−2.3		
16	−0.4	−2.2	−2.3	−2.1	−2.0	−2.0	−1.3	−1.5	−0.4	−1.6	−1.5	−1.7	−2.3	−2.1	−2.2		
17	−1.0	−2.2	−2.2	−2.1	−1.9	−1.7	−1.2	−1.6	−1.0	−1.4	−2.0	−1.7	−1.7	−2.1	−1.4		
18	−1.3	−2.2	−2.4	−1.9	−1.9	−1.5	−1.1	−1.8	−1.4	−1.0	−2.0	−1.4	−1.6	−2.0	−2.0		
19	−1.6	−2.0	−3.6	−2.2	−2.2	−1.6	−1.4	−1.7	−1.6	−0.8	−2.1	−1.6	−1.8	−2.0	−2.2		
20	−1.0	−2.1	−2.6	−2.8	−2.2	−1.5	−1.1	−1.6	−1.4	−2.0	−2.0	−1.6	−2.0	−2.1	−2.1		
21	−1.4	−2.2	−1.9	−2.4	−2.2	−1.5	−1.2	−1.6	−1.4	−1.8	−2.0	−1.5	−2.4	−2.2	−2.1		
22	−2.0	−2.2	−1.9	−1.9	−2.0	−1.5	−1.3	−1.5	−1.4	−1.7	−2.0	−1.3	−2.0	−2.2	−2.1		
23	−1.9	−2.3	−2.3	−1.9	−2.0	−1.3	−1.3	−1.2	−1.4	−1.2	−2.8	−1.6	−1.5	−2.3	−2.1		
24	−1.7	−2.3	−2.3	−1.9	−2.2	−1.3	−1.2	−1.4	−1.8	−1.9	−2.5	−1.9	−1.9	−2.3	−2.3		
25	−1.5	−2.3	−2.4	−1.9	−2.3	−1.4	−1.8	−1.4	−2.7	−1.7	−1.6	−2.0	−1.9	−2.3	−2.4		
26	−1.5	−2.4	−2.0	−1.9	−2.2	−1.3	−0.7	−1.6	−1.7	−1.8	−1.8	−2.0	−2.0	−2.2	−2.5		
27	−1.6	−2.4	−1.8	−1.9	−2.0	−1.2	−1.5	−1.7	−1.7	−2.0	−2.0	−1.8	−1.0	−2.4	−2.2		
28	−1.4	−2.5	−1.8	−2.0	−2.3	−1.3	−1.2	−1.6	−1.6	−2.3	−1.9	−2.0	−1.8	−2.2	−2.2		
29	−1.6		−2.0	−2.0	−1.7	−1.0	−1.2	−1.4	−1.4	−2.0	−1.4	−1.7	−2.3		−1.8		
30	−2.2		−2.4	−2.0	−1.6	−1.2	−1.0	−1.3	−1.4	−1.9	−2.0	−1.5	−2.1		−1.2		
31	−1.5		−2.0		−1.6		−1.1	−1.5		−1.6		−0.7	−2.2		−1.5		

Blank spaces—No record; gauge out of order.
U. S. Engineer Office, Buffalo, New York. Map No. 6A. Drawer No. 64.

WILLIAMS EXHIBIT 29 Sheet 17 (19 Sheets)

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

From record of self registering gage at

BUFFALO, N. Y.

In terms of U. S. Lake Survey adjusted levels of 1903.

1909.

Day	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	.....	.....	.....	572.47a	571.46	571.42
2	.....	.....	.....	572.11	572.14	571.34b
3	.....	.....	.....	571.93	571.90	571.49b
4	.....	.....	.....	571.83	571.82	571.55
5	.....	.....	.....	571.80	571.58	571.60
6	.....	.....	.....	571.92	571.25	573.11
7	.....	.....	.....	571.93	571.43	572.93
8	.....	.....	.....	571.89	571.50	573.60
9	.....	.....	.....	571.82	571.00	573.27
10	.....	.....	.....	571.96	571.51	572.43
11	.....	.....	.....	572.28	571.58	571.45
12	.....	.....	.....	573.90	571.52	570.74
13	.....	.....	.....	573.30	571.22	571.67
14	.....	.....	.....	572.88	571.53	573.60
15	.....	.....	.....	572.25	571.78	572.74
16	.....	.....	.....	572.78	571.41	572.17
17	.....	.....	.....	572.06	573.75	572.73
18	.....	.....	.....	571.73	571.87	572.90
19	.....	.....	.....	571.61	572.28	572.12
20	.....	.....	.....	571.40	572.01	572.11
21	.....	.....	.....	572.00	571.69	572.04
22	.....	.....	.....	572.40	571.43	572.05
23	.....	.....	.....	571.20	571.57	571.84
24	.....	.....	.....	571.48	570.87	571.56
25	.....	.....	.....	571.86	571.67	571.04
26	.....	.....	.....	572.10	571.55	571.43
27	.....	.....	.....	572.08	571.55	571.93
28	.....	.....	.....	571.79	571.60	571.79
29	.....	.....	.....	571.52	571.17	571.44
30	.....	.....	.....	571.53	571.43	571.74
31	.....	.....	.....	571.68	.....	571.59
Mean	.....	.....	.....	572.05	571.64	572.05

Note.—a=Partial day only.

b=Mean of partial day, the remaining hours of the day being supplied from mean stage range.

WILLIAMS EXHIBIT 29 (Sheet 18)
(19 Sheets)

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

from record of self-registering gage at

BUFFALO, N. Y.

1910.

Day	Jan.	Feb.	Mar.	Apr.	May	June
1	571.44	571.20	571.12	571.71	572.21	572.94
2	571.36	571.10	571.26	571.69	572.29	572.58
3	572.12	571.04	571.28	571.59	572.37	572.57
4	570.92a	571.50	571.28	571.75	572.50	572.27
5	571.56	571.21	571.34	571.74	572.53	572.46
6	571.33	571.16	571.53	572.04	572.61	572.65
7	571.76	571.09	571.97	572.18	572.47	572.77
8	571.34	571.04	571.62	571.96	572.45	572.69
9	571.41	571.07	571.48	571.92	572.78	572.43
10	571.13	571.07	571.42	571.88	572.70	572.26
11	571.13	570.83	571.41	571.61	572.62	572.29
12	571.07	571.01	571.44	571.70	572.69	572.78
13	c	571.25	571.80	571.72	572.49	572.63
14	c	571.04	571.80	571.76	572.51	572.63
15	570.92	570.97	571.66	571.80	572.44	572.63
16	571.15	571.14	571.60	571.63	572.35	572.54
17	570.99	570.84	571.47	571.83	572.52	572.61
18	571.92	571.19	571.38	571.78	573.18	572.68
19	571.65	571.05	571.60	572.10	572.45	572.57
20	571.22	570.89	571.64	571.88	572.44	572.55
21	571.19	570.97	571.58	572.05	572.51	572.55
22	572.32	570.98	571.66	572.00	572.45	572.54
23	571.64	571.36	571.43	572.13	572.64	572.56
24	571.34	570.95	571.69	572.17	572.58	572.20
25	571.19	570.93	571.83	572.19	572.61	572.39
26	571.10	570.89	571.63	572.22	572.70	572.41
27	571.72	570.97	571.50	572.29	572.60	572.59
28	571.25	570.99	571.81	572.02	572.64	572.60
29	571.37	.....	571.66	572.15	572.60	572.55
30	571.18	.....	571.69	572.62	572.88	572.52
31	571.28	.....	571.96	.....	572.79	.....
Mean	571.38	571.06	571.57	571.97	572.57	572.55

Note.—a=Mean of partial day only.
b=
c=No record.

WILLIAMS EXHIBIT 29 Sheet 19 (19 Sheets)

ELEVATIONS OF WATER SURFACE OF LAKE ERIE

from record of self-registering gage at

BUFFALO, N. Y.

In terms of U. S. Lake Survey adjusted levels of 1903.

1910.

Day	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	572.58	572.35	571.78	572.42	571.71	571.42
2	572.48	572.28	571.91	571.55	572.06b	571.49
3	572.52	572.22	572.50a	571.62	571.49b	571.46
4	572.02	572.69	c	571.94	571.48b	571.16
5	572.12	572.84	572.01	571.74	571.67	570.48
6	572.30	572.45	572.43	571.86	c	570.56
7	572.44	572.13	572.09	571.66	c	572.19
8	572.39	572.17	571.99	571.83	c	572.23
9	572.46	572.18	572.09	572.08	c	571.13a
10	572.47	572.32	571.80	571.92	c	c
11	572.42	c	571.85	572.31	c	c
12	572.42	572.01	571.92	571.53	572.06	c
13	572.62	572.08	571.72	571.50	572.14	572.18a
14	572.38	572.10b	571.68	551.93	571.59	573.53
15	572.39	572.04	571.82	571.99	571.87	571.86
16	572.18	571.98	571.71	571.97	571.88	571.22
17	571.95	572.01	571.80	571.65	571.80	571.59
18	572.03	572.16	571.83	571.76	571.90	571.24
19	572.23	572.06	571.44	571.78	571.48	572.29
20	572.29	572.01	571.57	571.47	571.22	571.73
21	572.39	571.97	571.72	571.36	571.69	571.27
22	572.47	572.11	571.27	573.11	571.47	571.18
23	572.28	572.04	571.66	572.04	571.53	571.27
24	572.42	572.10	571.52	572.05	571.79	571.67
25	572.64	572.45	571.96	571.85	571.68	571.09
26	572.46	572.30	571.52	571.69	571.42	571.56
27	572.49	572.03	572.09	572.63	570.60	571.40
28	572.35	571.81	571.82	572.47a	571.49	570.97
29	572.38	571.28	571.57	571.82	572.32	570.76
30	572.45	571.73	571.80	572.34	572.07	c
31	572.36	571.88	.....	571.80	.....	c
Mean	572.37	572.13	571.83	571.92	571.68	571.50

Note.—a=Mean of partial day only.
b=Mean of partial day only, using also mean of range.
c=No record, driving clock stopped.

WILLIAMS EXHIBIT 30 Sheet 1 (5 Sheets)

MONTHLY MEANS OF LAKE LEVELS

as derived from

U. S. Lake Survey Automatic-gage Records

Date	Lake Ontario at Tibbetts Pt.	Lake Erie at Buffalo	Lake Erie by Staff gage at Cleveland, Ohio	Lakes Mich.-Huron at Harbor Beach
1904				
July	247.78	573.41	.....	581.55
Aug.	247.56	573.12	.....	581.53
Sept.	247.17	572.84	.....	581.36
Oct.	246.84	572.61	.....	581.26
Nov.	246.33	572.31	.....	580.95
Dec.	245.75	572.13	.....	580.50
1905				
Jan.	245.60	571.74	.....	580.38
Feb.	245.28	571.23	.....	580.30
Mar	245.06	571.32	.....	580.29
Apr.	245.80	571.79	.....	580.66
May	246.13	572.38	.....	580.95
June	246.47	572.97	.....	581.40
July	246.89	573.28	.....	581.57
Aug.	246.68	573.06	.....	581.56
Sept	246.72	572.86	.....	581.45
Oct.	246.48	572.65	.....	581.22
Nov.	246.21	572.29	.....	580.93
Dec.	246.01	572.44	.....	580.67
1906			Shenehon	
Jan.	246.23	572.39	.....	580.53
Feb.	246.02	571.95	571.93	580.69
Mar.	245.76	571.72	571.71	580.76
Apr.	246.05	.....	572.10	580.94
May	.....	.....	572.39	581.20
June	.....	.....	572.58	581.33
July	246.40	.....	572.67	581.45
Aug.	246.14	.....	572.65	581.35
Sept.	245.78	.....	572.40	581.12
Oct.	245.66	.....	572.26	580.87
Nov.	245.55	.....	572.22	580.68
Dec.	.....	.....	.....	.....

F.G.R. Doc. 31, 1906

WILLIAMS EXHIBIT 30 Sheet 2 (5 Sheets)

DAILY MEAN ELEVATIONS OF WATER SURFACE OF LAKE ONTARIO

from self-registering gage records and tri-daily staff-gage readings

AT OSWEGO, N. Y.

in terms of the Lake Survey adjusted levels of 1903.

1900.

Day	Sept. a	Oct. a	Nov. a	Dec. b
1	245.31	244.90	244.43	244.78
2	245.27	244.84	244.60	244.82
3	245.33	244.83	244.56	244.72
4	245.33	244.83	244.51	244.72
5	245.33	244.83	244.67	244.92
6	245.34	244.82	244.62	245.02
7	245.24	244.78	244.43	244.92
8	245.20	244.95	244.59	244.92
9	245.22	244.89	244.98	245.02
10	245.13	244.89	244.73	244.89
11	245.05	244.89	244.46	245.02
12	245.39	244.85	244.54	244.82
13	245.14	244.79	244.48	245.15
14	245.15	244.80	244.51	244.92
15	245.05	244.78	244.54	244.92
16	245.10	244.90	244.39	244.92
17	245.16	244.76	244.28	244.82
18	245.11	244.81	244.34	244.72
19	244.96	244.69	244.38	244.75
20	244.90	244.60	b244.42	244.82
21	245.06	244.59	244.94	244.75
22	245.09	244.57	244.53	244.69
23	245.04	244.55	244.62	244.62
24	245.04	244.64	244.42	244.89
25	244.97	244.56	244.43	244.82
26	244.94	244.52	b244.50	244.92
27	245.01	244.63	b244.52	244.72
28	244.96	244.59	b244.65	244.82
29	244.91	244.55	244.46	244.89
30	244.95	244.46	244.68	244.62
31	.....	244.35	.....	244.65
Mean	245.12	244.72	244.54	244.84

Note.—(a), from self-registering gage records.
(b), from tri-daily staff-gage readings.

WILLIAMS EXHIBIT 30 Sheet 3 (5 Sheets)

DAILY MEAN ELEVATIONS OF WATER SURFACE OF LAKE ONTARIO

from self-registering gage records and tri-daily staff-gage readings

AT OSWEGO, N. Y.

in terms of the Lake Survey adjusted levels of 1903.

1901

Day	April	May	June	July
	b	a	a	a
1	245.12	246.10	245.92	245.92
2	245.09	246.08	245.91	245.94
3	245.12	246.14	245.99	245.94
4	245.39	246.09	245.97	245.90
5	245.32	246.06	245.93	245.85
6	245.32	246.02	245.95	245.88
7	245.32	246.00	246.01	245.92
8	245.52	245.96	246.10	245.94
9	245.55	245.95	246.11	245.90
10	245.52	245.93	246.04	245.85
11	245.55	245.95	246.01	245.88
12	245.52	245.89	246.03	245.79
13	245.55	245.93	246.02	245.77
14	245.55	245.90	246.00	245.74
15	245.52	245.88	246.00	245.74
16	245.55	245.86	245.96	245.74
17	245.50	245.85	245.95	245.75
18	245.50	245.86	245.95	245.75
19	245.55	245.83	245.95	245.72
20	245.62	245.82	245.96	245.66
21	245.72	245.77	245.98	245.69
22	245.80	245.78	245.96	245.71
23	245.95	245.83	246.03	245.69
24	246.02	245.87	246.04	245.68
25	246.02	245.85	246.01	245.53
26	246.05	245.81	246.00	245.44
27	246.00	245.82	246.00	245.40
28	246.00	245.84	246.01	245.44
29	246.02	245.81	246.02	245.56
30	246.12	245.85	246.01	245.65
31	.....	245.85	.....	245.68
Mean	245.63	245.91	245.99	245.74

Note.—(a), from self-registering gage records.
(b), from tri-daily staff-gage readings.

WILLIAMS EXHIBIT 30 Sheet 4 (5 Sheets)

DAILY MEAN ELEVATIONS OF WATER SURFACE OF ST. LAWRENCE RIVER

from self-registering gage records

AT OGDENSBURG.

In terms of the Lake Survey adjusted levels of 1903.

1901.

Day	April	May	June	July
1	244.01	244.89	244.87	244.99
2	243.91	244.95	244.85	245.14
3	243.71	244.84	245.15	244.94
4	243.98	244.97	245.12	244.82
5	244.18	244.91	244.97	244.70
6	244.09	244.86	245.03	244.96
7	244.19	244.93	245.13	245.11
8	244.39	244.86	245.22	244.81
9	244.30	244.82	245.16	244.95
10	244.22	244.77	245.10	244.96
11	244.30	244.88	245.03	244.72
12	244.36	245.03	244.95	244.75
13	244.35	245.19	244.91	244.85
14	244.35	245.00	245.01	244.92
15	244.39	244.97	244.49	244.92
16	244.38	244.91	244.78	244.88
17	244.36	244.83	244.83	244.87
18	244.53	244.84	244.85	244.79
19	244.45	244.52	244.92	244.68
20	243.73	244.00	244.89	244.77
21	243.87	244.72	244.98	244.80
22	244.39	244.75	244.91	244.77
23	244.54	245.00	245.05	244.77
24	244.67	244.14	245.07	244.64
25	244.67	244.42	245.01	244.51
26	244.68	244.80	244.99	244.46
27	244.86	244.82	245.06	244.53
28	244.93	244.65*	245.06	244.55
29	244.93	.....	245.11	244.58
30	244.85	.....	245.19	244.87
31	.....	244.89*	.....	244.88
Mean	244.35	244.82	244.99	244.81

Note.—May 29th and 31st records are for partial days only.

WILLIAMS EXHIBIT 30 Sheet 5 (5 Sheets)

DAILY MEAN ELEVATIONS OF WATER SURFACE OF ST. LAWRENCE RIVER.

from self-registering gage records

AT OGDENSBURG.

1900.

Day	Sept.	Oct.	Nov.	Dec.
1	.....	243.98	243.95	243.91
2	.....	243.97	244.12	243.84
3	.....	244.07	243.69	243.88
4	.....	244.06	243.87	243.63
5	.....	244.04	243.80	243.78
6	.....	243.77	243.81	243.99
7	.....	244.10	243.77	243.97
8	.....	244.02	243.60	244.31
9	.....	243.87	243.65	244.01
10	.....	243.87	243.95	243.91
11	.....	244.04	243.70	.....
12	.....	243.98	244.08	243.91
13	.....	243.87	243.49	244.38
14	.....	243.82	243.74	243.82
15	.....	243.98	243.94	243.80
16	.....	243.83	243.54	243.82
17	244.20	243.99	243.60	243.73
18	243.99	244.02	243.74	243.72
19	244.00	243.65	242.97	244.25
20	244.35	243.84	243.60	243.96
21	244.36	243.90	244.59	243.75
22	244.23	243.77	243.79	243.83
23	244.16	243.79	244.01	243.88
24	244.15	243.84	243.36	244.07
25	244.06	243.59	243.01	244.14
26	244.13	243.78	242.68	244.03
27	244.13	243.73	243.52	243.97
28	244.04	243.70	243.52	244.02
29	244.02	243.73	243.74	244.30
30	244.01	243.07	243.83	244.26
31	.....	243.70	.....	243.88
Mean	244.14	243.85	243.69	243.96

Note.—Gage was started on September 17th, 1900.
Elevations are in terms of Lake Survey adjusted levels of 1903.

WILLIAMS EXHIBIT 31

Sheet 1
(3 Sheets)

TABLE I—LAKE SUPERIOR DRAINAGE AREA
Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1898	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1.8	1.1	.....
1899	1.5	1.3	1.7	2.2	3.2	3.7	2.2	3.4	3.5	2.4	0.5	2.0	27.6
1900	1.3	1.1	0.8	1.1	0.8	2.1	3.4	4.7	6.0	2.7	1.6	1.1	26.7
1901	1.4	0.5	2.0	1.1	1.5	3.9	4.8	2.2	3.0	3.0	1.7	1.7	26.8
1902	1.0	1.2	0.8	1.5	2.5	2.9	2.8	2.6	2.9	2.8	2.7	2.2	26.8
1903	1.1	0.9	1.7	1.8	3.9	1.4	3.8	2.9	3.8	2.9	2.3	1.5	28.0
1904	1.3	0.7	1.7	0.9	2.7	2.9	2.7	3.1	4.0	3.9	0.8	2.1	26.8
1905	1.2	0.8	2.0	1.7	2.8	4.3	4.3	2.3	4.7	2.7	2.7	1.0	30.5
1906	2.08	0.92	1.57	1.23	3.36	4.85	1.70	3.55	3.00	2.87	3.17	1.82	30.12

TABLE II—LAKE MICHIGAN DRAINAGE AREA
Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	2.50	0.96	0.81	1.41	3.29	1.84	1.80	3.28	2.51	0.91	2.92	4.18	26.41
1896	1.25	1.26	1.53	3.60	4.07	2.82	4.05	3.42	5.45	1.53	2.09	2.18	33.25
1897	4.02	1.37	3.03	2.97	2.42	3.40	2.78	1.94	1.49	1.85	2.85	2.21	30.33
1898	2.70	2.20	3.51	1.84	3.00	3.67	2.10	3.33	2.84	4.24	2.30	1.52	33.25
1899	1.61	1.41	2.81	1.55	3.80	3.19	3.81	1.55	2.94	2.68	1.14	2.25	28.74
1900	1.31	2.87	1.64	1.90	2.48	2.65	5.53	3.95	3.66	3.24	3.32	0.75	33.30
1901	1.67	1.38	3.04	1.09	2.40	2.91	4.29	2.36	2.50	3.36	1.36	2.23	28.59
1902	0.75	1.29	2.49	1.83	4.37	5.17	5.16	1.41	3.68	2.19	2.65	2.29	33.28
1903	1.62	2.03	2.18	3.15	2.86	2.44	4.35	4.97	3.77	2.02	1.63	1.99	33.01
1904	1.67	1.93	3.39	2.21	4.29	2.04	2.91	3.08	3.97	2.98	0.40	1.82	30.69
1905	1.61	1.52	2.29	2.23	4.96	4.96	4.34	3.50	3.06	2.86	2.18	1.50	35.03
1906	2.79	1.43	2.24	1.78	2.90	3.87	2.40	3.24	2.97	2.95	3.37	2.32	32.35

TABLE III—LAKE HURON DRAINAGE AREA

Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.75	1.35	1.18	1.50	2.41	1.50	1.54	2.81	2.91	1.86	3.18	3.84	27.92
1896	2.37	1.94	1.37	2.08	2.65	2.39	2.28	3.84	4.71	2.00	3.16	1.80	30.59
1897	3.47	1.82	2.96	3.01	3.45	2.59	4.17	2.75	1.06	3.27	3.21	3.40	35.16
1898	2.95	2.55	2.88	1.31	2.69	3.41	1.28	3.16	2.67	4.20	2.08	2.74	31.90
1899	2.25	1.32	3.49	1.47	3.25	3.44	3.48	1.04	3.38	2.78	1.20	3.39	31.09
1900	1.81	3.62	1.68	1.29	2.36	3.09	4.24	2.97	3.52	2.45	3.87	1.56	32.46
1901	2.16	1.49	2.85	1.55	2.81	2.28	4.21	2.86	2.41	3.16	2.04	2.62	30.44
1902	1.46	1.33	2.81	1.89	3.20	4.16	4.56	2.32	3.57	3.22	2.81	2.23	33.68
1903	2.29	2.06	1.99	1.79	2.48	2.94	3.52	3.99	3.68	2.86	2.01	3.10	33.31
1904	1.99	2.21	2.82	2.44	3.75	2.67	2.75	3.12	3.88	2.62	0.99	2.19	31.43
1905	2.17	1.91	2.23	1.63	4.08	3.74	3.89	2.53	3.00	3.48	2.56	1.51	33.03
1906	2.86	1.59	2.10	1.58	2.45	4.07	2.70	2.79	2.38	4.16	2.92	2.50	32.10

WILLIAMS EXHIBIT 31
Sheet 2
(3 Sheets)

TABLE IV—LAKE HURON-MICHIGAN DRAINAGE AREA
Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.15	1.16	1.00	1.50	2.83	1.66	1.66	3.03	2.72	1.41	3.05	4.00	27.17
1896	1.83	1.61	1.44	2.80	3.32	2.59	3.12	3.63	5.06	1.77	2.64	1.98	31.79
1897	3.73	1.60	2.99	2.99	2.95	2.98	3.50	2.36	1.26	2.59	3.03	2.83	32.81
1898	2.83	2.38	3.17	1.56	2.83	3.53	1.67	3.24	2.75	4.21	2.18	2.15	32.50
1899	2.25	1.36	3.16	1.51	3.51	3.32	3.63	1.28	3.17	2.73	1.17	2.84	29.93
1900	1.57	3.26	1.66	1.58	2.41	2.88	4.85	3.43	3.58	2.82	3.60	1.17	32.81
1901	1.92	1.44	2.94	1.33	2.61	2.58	4.24	2.62	2.45	3.25	1.71	2.43	29.52
1902	1.12	1.31	2.65	1.86	3.80	4.64	4.84	1.88	3.62	2.72	2.73	2.27	33.44
1903	1.97	2.36	2.08	2.44	2.66	2.70	3.91	4.45	3.72	2.46	1.83	2.57	33.15
1904	1.83	2.07	3.00	2.33	4.00	2.37	2.82	3.10	3.92	2.79	0.71	2.01	31.04
1905	1.91	1.72	2.26	1.91	4.51	4.32	4.10	2.99	3.02	3.18	2.38	1.66	33.96
1906	2.82	1.49	2.18	1.70	2.72	3.95	2.57	3.05	2.72	3.44	3.19	2.39	32.22

TABLE V—LAKE ST. CLAIR DRAINAGE AREA
Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.08	0.95	1.41	1.57	2.84	1.29	1.98	2.57	2.87	1.36	4.03	4.26	28.21
1896	1.42	2.11	1.86	2.58	2.69	3.42	4.82	4.18	4.04	1.82	2.22	1.55	33.31
1897	2.53	1.56	3.24	2.47	3.89	2.72	3.61	2.71	0.83	1.56	4.98	2.48	32.58
1898	3.33	2.74	3.24	1.86	2.11	3.09	1.67	2.21	3.16	4.82	2.98	2.56	33.77
1899	1.95	1.72	3.93	0.65	3.39	1.97	2.13	0.59	2.75	3.39	1.73	2.71	26.91
1900	1.68	4.02	2.28	1.55	2.84	3.28	3.92	2.87	1.65	2.53	3.52	0.58	30.72
1901	1.90	1.94	2.08	1.82	2.78	1.91	3.76	2.22	2.14	1.71	1.63	3.36	27.23
1902	1.14	1.05	2.62	1.18	3.47	5.85	6.94	1.72	5.58	2.59	1.61	2.02	35.77
1903	1.88	2.71	1.68	3.41	2.64	3.83	4.64	4.13	2.58	2.23	1.81	2.22	33.76
1904	3.16	2.17	3.21	2.52	2.58	1.98	3.32	4.06	2.88	2.02	0.62	2.01	30.53
1905	1.97	1.90	1.35	1.96	3.80	4.04	3.97	3.40	2.53	2.78	2.77	1.71	32.18
1906	2.13	1.07	2.01	1.79	2.92	4.04	3.72	2.89	1.78	5.19	2.32	3.39	33.26

TABLE VI—LAKE ERIE DRAINAGE AREA

Mean monthly and annual rainfall, in inches

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.31	0.97	1.44	1.78	2.27	1.94	2.00	2.94	2.33	1.40	4.37	4.33	29.08
1896	1.78	2.61	2.60	2.92	2.37	3.76	6.44	3.18	4.65	1.36	2.21	1.78	35.75
1897	2.49	1.87	3.59	2.72	3.83	2.76	4.49	2.92	0.80	1.18	5.36	2.43	34.44
1898	3.88	2.53	4.09	2.03	3.17	3.05	2.80	3.45	3.09	4.52	3.21	2.70	38.52
1899	2.48	1.91	3.97	1.12	4.20	1.97	3.24	1.22	3.25	2.72	1.69	3.20	30.97
1900	2.11	4.03	2.53	1.86	2.28	2.91	4.93	2.99	2.01	2.60	4.16	1.05	33.46
1901	2.03	1.70	2.72	3.08	3.83	3.01	3.30	3.12	2.81	1.59	2.09	3.64	32.92
1902	1.41	1.13	2.54	2.08	3.49	6.47	6.25	1.61	4.85	2.43	1.97	2.87	37.10
1903	2.08	3.36	2.30	4.09	2.13	3.86	4.63	4.82	2.04	2.56	1.95	2.26	36.08
1904	4.15	2.95	4.50	3.23	3.66	2.21	4.21	3.27	2.76	1.95	0.46	2.32	35.67
1905	2.15	1.66	1.78	2.72	4.57	4.77	4.19	3.61	2.98	2.88	2.73	1.90	35.94
1906	1.71	1.03	2.78	2.01	2.60	3.22	4.09	3.95	2.69	4.36	2.57	3.47	34.48

WILLIAMS EXHIBIT 31.

Sheet 3
(3 Sheets)

TABLE VII.—LAKE ONTARIO DRAINAGE AREA.

Mean monthly and annual rainfall, in inches.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1895	3.27	1.59	1.50	1.77	2.52	2.13	2.51	3.43	2.52	1.63	3.71	4.00	30.58
1896	2.43	4.09	3.21	1.24	2.41	2.60	3.86	2.46	4.52	2.33	2.99	1.37	33.51
1897	2.52	1.81	3.22	2.66	3.41	2.95	5.25	2.36	1.56	1.29	4.41	3.39	34.83
1898	3.31	2.26	2.31	2.06	3.10	2.87	1.72	4.34	3.24	4.82	2.73	2.63	35.61
1899	2.22	1.61	3.48	1.46	3.26	2.01	2.87	1.34	3.66	2.89	1.74	3.91	30.45
1900	2.87	3.84	3.42	1.51	1.80	2.56	4.21	2.37	2.38	3.07	5.15	2.00	35.18
1901	2.33	1.76	2.98	4.16	4.45	3.01	3.87	3.96	3.03	1.54	2.62	4.10	37.81
1902	2.36	2.25	2.73	2.67	2.55	4.48	6.45	2.39	2.81	3.24	1.66	2.87	36.46
1903	2.79	2.63	3.31	2.54	1.01	5.11	4.00	4.76	1.52	3.93	1.72	2.61	35.93
1904	3.30	2.59	3.12	3.11	3.62	3.18	4.47	3.41	3.69	2.46	0.67	2.27	35.89
1905	2.19	1.84	1.70	1.85	2.87	4.99	4.45	3.77	2.59	3.56	2.20	2.87	35.58
1906	2.02	1.08	2.69	1.79	2.94	5.05	3.08	3.13	2.97	4.67	2.36	2.73	34.51

WILLIAMS EXHIBIT 32.

F F F 2.

ENGINEER OFFICE, U. S. ARMY,
Detroit, Mich., July 20, 1903.

GENERAL: I have the honor to submit with my annual report for the fiscal year ending June 30, 1903, a special report on the outflow, rainfall, and evaporation in the valley of the Northern and Northwestern Lakes.

Very respectfully, your obedient servant,

WM. H. BIXBY,
Major, Corps of Engineers.

Brig. Gen. G. L. GILLESPIE,
Chief of Engineers, U. S. A.

U. S. ENGINEER OFFICE, JONES BUILDING,
Detroit, Mich. June 25, 1903.

MAJOR: I have the honor to submit the following discussion of the outflow, rainfall, and evaporation in the valley of the Great Lakes:

DRAINAGE BASINS.

The outlines and areas of the drainage basins of the several lakes were first determined. Plate I is a map of these basins. This map was compiled from the best topographical maps available. It was also compared with a similar map prepared by the Deep Waterway Commission. The watershed or boundary of the basin was determined by a study of the sources of the streams. In the United States the land survey maps show these with considerable accuracy. It is likely that the township in which a stream has its rise is in almost all cases correctly given, and the location of the source is known within less than 6 miles. In a portion of Canada the maps have equal accuracy.

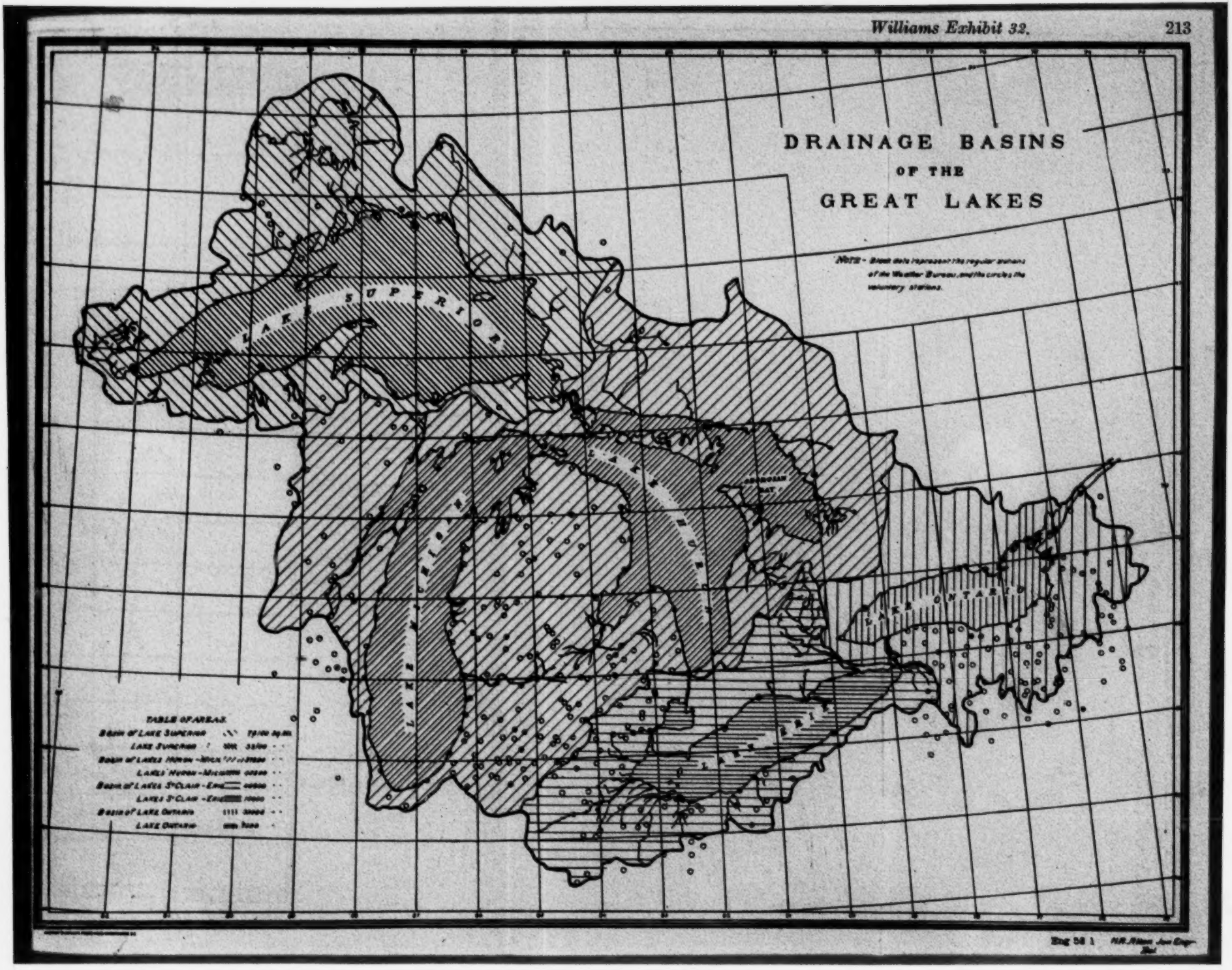
In order to make an approximate estimate of the error in the determination of the area of the drainage basin, it might reasonably be assumed that the best located part of the boun-

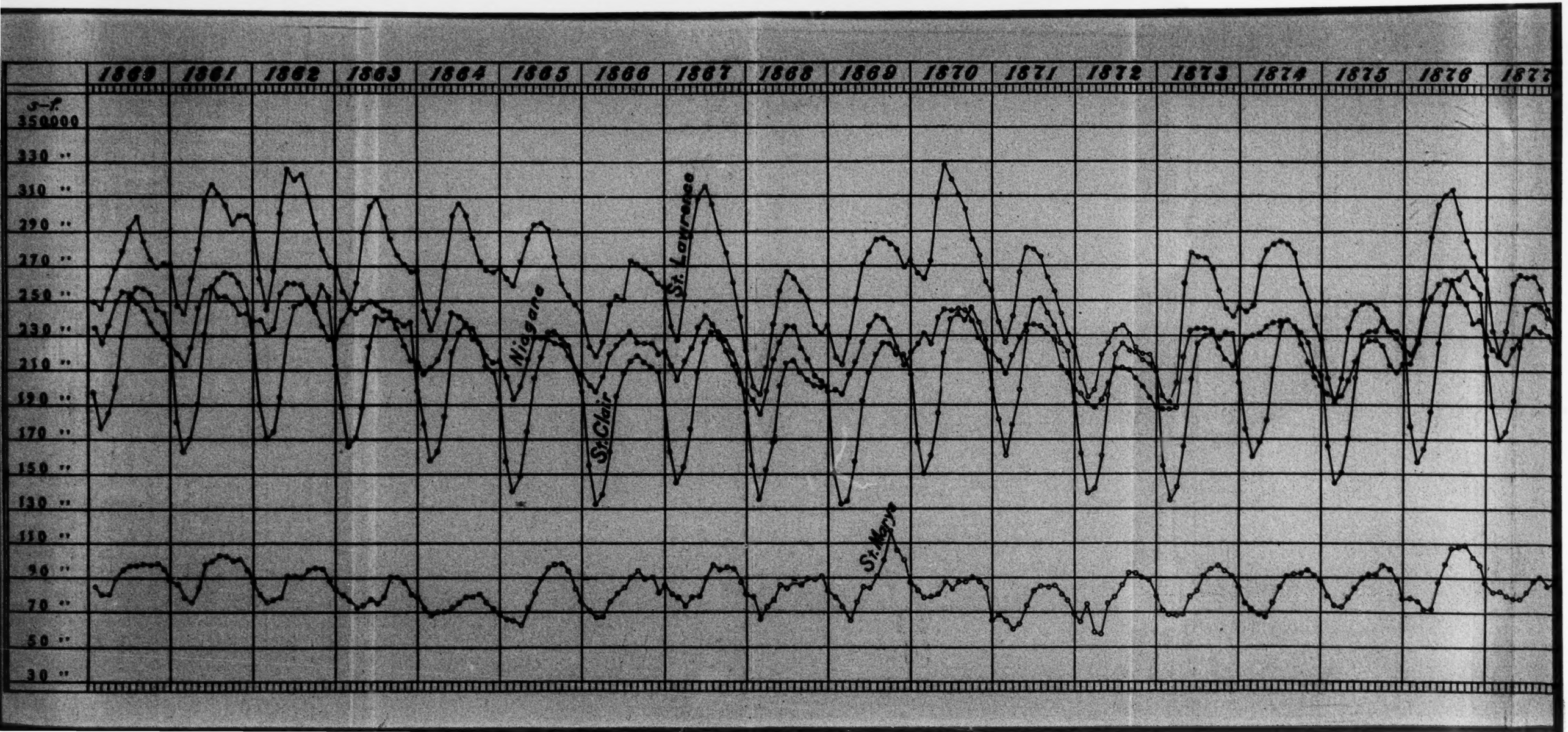
dary was never more than 6 miles in error, and this not oftener than once in a hundred miles. This error would sometimes be inside the basin and sometimes outside as a compensating error. Since there is about 2,500 miles of the developed boundary line known with this accuracy, there might be about 500 miles uncompensated, which would make a possible error of about 1,500 square miles. In the northwestern part there is about 900 miles of the boundary where the maps are less accurate, and it might be reasonably assumed that the location is never more than 20 miles in error, and this not oftener than once in a hundred miles. Then the uncompensated possible error in this part of the boundary would be about 3,000 square miles, and the total possible error with this assumption would be about 4,500 square miles, or about 1½ per cent. of the total area of the basins. It is therefore probable that the areas of the several basins are correctly determined within less than 2 per cent.

After the boundary line was drawn on the map the area included by it was determined as follows:

Quadrilaterals of one degree or less in extent, bounded by meridians and parallels, were selected so as to completely cover the basin; this gave a polygon, the sides of which were meridians and parallels. The total area of this polygon was determined accurately from geodetic tables of areas. Those small parts of the polygon which extended outside of the boundaries of the basin were measured on the map with a planimeter and subtracted, the remainder being the area of the basin. This work was done with care and checked, and it is believed that the areas of the lakes and basins as herewith given on Plate I are as accurate as extant maps will permit.

In determining the area of the lakes their connecting waters were included; the lines of division between the lakes were chosen at the points where the discharge measurements were made, viz, Sault Ste. Marie, Port Huron, Buffalo, and Ogdensburg. For this determination the lake survey maps were used and the same method followed as for the entire basin. It is seen from this map that the northeast watershed approximates a straight line for a distance of more than 800 miles—that is, a straight line could be drawn for that distance so that at no point would its distance from the watershed be more than 30 miles. It will also be noticed that at certain points the shores of Lakes Superior, Michigan, and Erie approach to within less than 10 miles of the boundaries of their basins.


DRAINAGE BASINS
OF THE
GREAT LAKES
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
LAKE ERIE
LAKE ONTARIO
TABLE OF AREAS.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Niagara
St. Clair
St. Lawrence
St. Marys

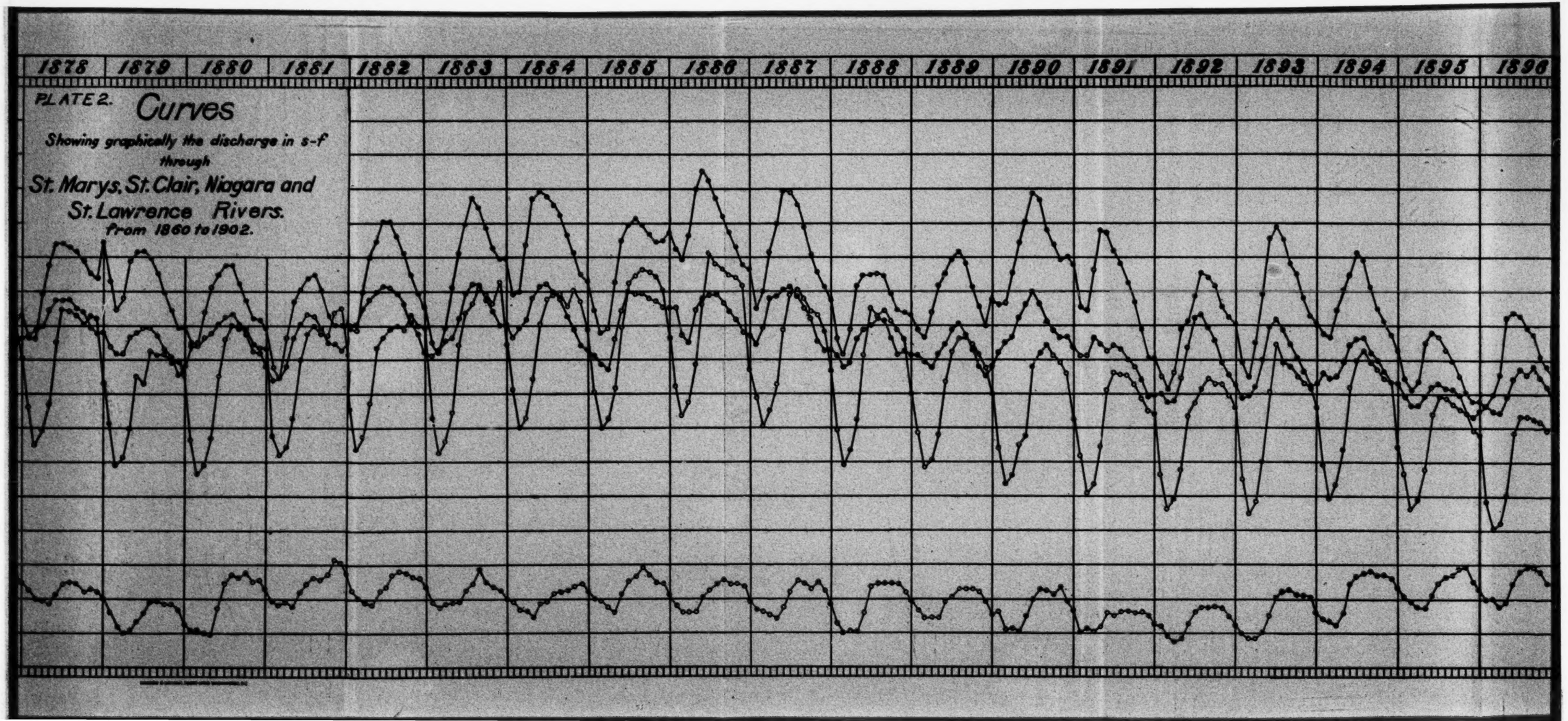
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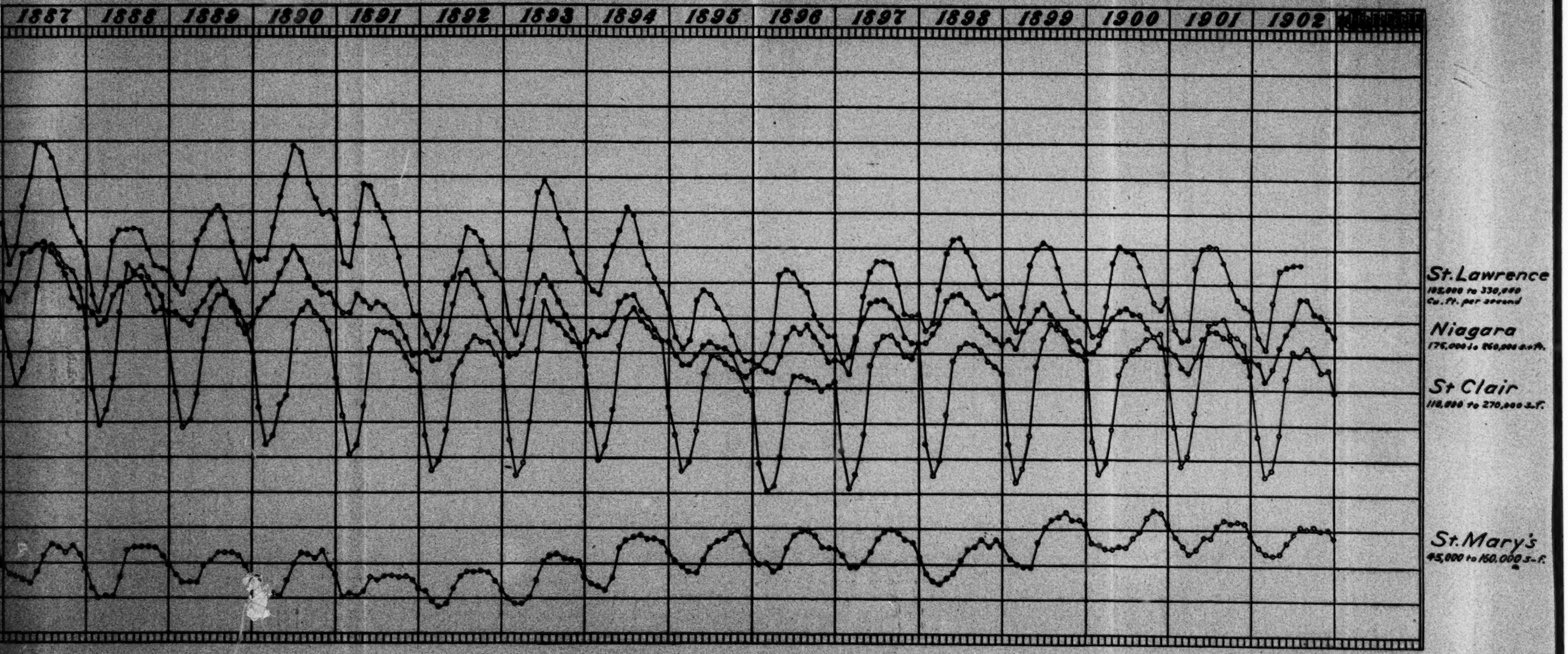
PLATE 2.
Curves
Showing graphically the discharge in s-f through
St. Marys, St. Clair, Niagara and St. Lawrence Rivers.
From 1860 to 1902.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1898
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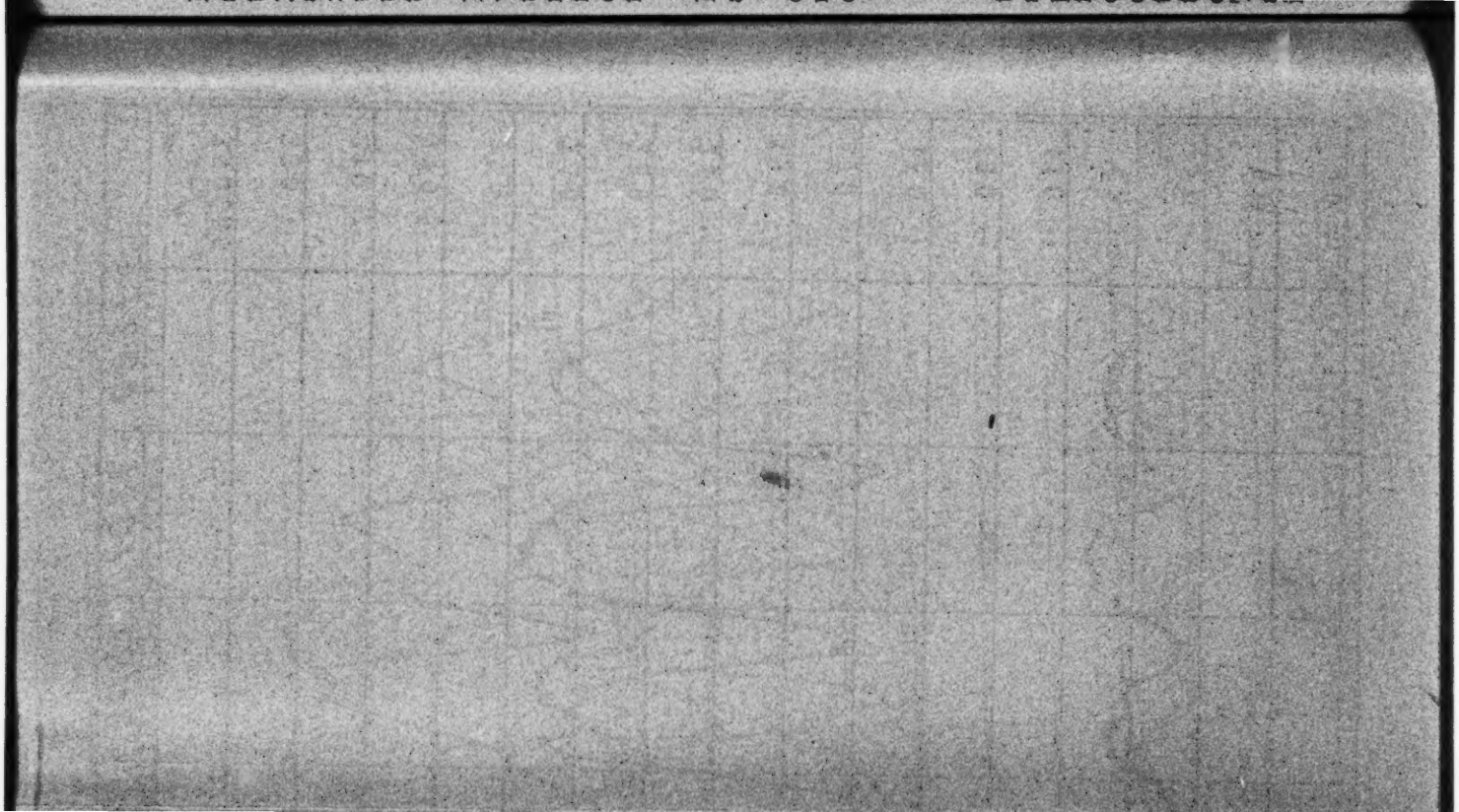
1900
1901
1902
St. Lawrence
185,000 to 330,000
Cu. Ft. per second
Niagara
176,000 to 260,000 c.f.
St Clair
118,000 to 270,000 c.f.
St. Mary's
45,000 to 150,000 c.f.
H.R. Allen Jun. Engr
Del.

Eng 58 1



LAKE ELEVATIONS.

The changes in the elevation of the surfaces of the Great Lakes, and consequently of the rivers connecting them, are small, the mean annual change being less than 2 feet, while the extreme range in monthly means for the last forty-two years is less than 5½ feet. The records of the elevations of all the lakes, except St. Clair, since 1860 are continuous and reasonably trustworthy. They have been published from year to year in the Report of the Chief of Engineers, from which they have been collected and are herewith given in Tables I to V.

The elevations of Lake St. Clair, herewith given in Table III, are not all directly observed; before 1872 no observations were made at Lake St. Clair; all the elevations given in the tables before that date and a few after it have been computed from the observed elevations of Lakes Huron and Erie. The formula used for such computations is taken from page 5397 of the Report of the Chief of Engineers for 1900, and is as follows:

St. Clair Flats=574.06+.407(H—580)+.452(E—570) where H=elevation of Lake Huron and E=elevation of Lake Erie, as herewith given in Tables II and IV.

For Lake St. Clair the elevation for the summer months only have been used, as the elevations during the winter months are often seriously disturbed by the ice, as discussed on page 2822 of Report of Chief of Engineers for 1902.

OUTFLOW AND DISCHARGE FORMULAE.

The outflow from the lakes has been measured at different times by the United States lake survey; the measurements since 1896 have been made with modern and improved appliances; the results have been very accordant. The discharge formulas derived from this later work have been used in this discussion. It is found that within the small observed range of the surface elevation the discharge is so near a linear function of the surface elevation that one can be derived from the other with considerable accuracy; therefore, the discharge can be determined whenever the surface elevation is known. This has been done for the years 1860 to 1902, and the results are herewith given in Tables VI to IX, and also shown graphically in Plate II.

The discharge from Lake Superior was measured at Sault Ste. Marie from 1896 to 1899, and discharge formulae were deduced therefrom in 1900.

Between 1887 and 1892 the outlet of Lake Superior was somewhat contracted by the building of the International Bridge piers at Sault Ste. Marie, and also by the closing of some of the small streams on both sides of the river. These changes make the discharge formulae different for different periods, as follows:

Before 1888, discharge in s-f=46,047+19,429 x (elev.—600).

From 1888 to 1895, inclusive, discharge in s-f=39,798+17,656 x (elev.—600).

From 1896 to 1898, inclusive, discharge in s-f=43,466+17,656 x (elev.—600).

After 1898, discharge in s-f=49,235+17,656 x (elev.—600).

In these formulae "elevation" means the elevation of lake surface as herewith given in Table I.

The data and methods used in determining such formulae, not having as yet been printed or otherwise published, are herewith attached and marked "Appendix A."

The outflow from Lakes Michigan and Huron was measured at Port Huron from 1898 to 1900. The results are given on pages 2819 et seq. of the Report of the Chief Engineers for 1902. It was found that the discharge of St. Clair River was not exactly a linear function of the surface elevation of Lake Huron, but was modified by two causes—first, the surface elevation of Lake St. Clair, and, second, ice during the winter season.

The formula for the discharge of St. Clair River during the summer months includes the surface elevation of both Lakes Huron and St. Clair. It is given on page 2821 of the Report of the Chief of Engineers for 1902, as follows:

Discharge in s-f=190,700+37,500(H—580 ft.)—18,000(St. Clair—575 ft.), in which H=the surface elevation of Lake Huron as herewith given in Table II, and St. Clair=the surface elevation of Lake St. Clair as herewith given in Table III. This formula is used in computing the discharge of the St. Clair River for the summer months—June to November, inclusive. For the winter months—December to April, inclusive—this formula is not applicable because of the ice effects.

A formula for the discharge of St. Clair River when the elevation of Lake Huron is alone considered is given on page 5362 of the Report of the Chief of Engineers for 1900, as follows:

Discharge in s-f=194,900+19,060 x (H—580 ft.), H being the elevation of Lake Huron as given in Table II.

During the winters of 1900, 1901, and 1902 the ice effects were measured. The results are given on page 2837 of the Report of the Chief of Engineers for 1902, and show that the discharge from Lake Huron as computed from the preceding formula was diminished by ice, as follows:

	Second-feet.
December	8,600
January	41,750
February	60,833
March	55,700
April	39,550
May	11,000

Since these three years' observations are all that is known of ice effects it is assumed that they show the average effect of ice. Therefore the discharge for the winter months was first computed from the preceding formula and then each month reduced by the quantities in the above table. This determination of the winter discharge of St. Clair River has the least data and is the most involved and uncertain of any of the discharge determinations. The ice effects are certainly very erratic, and the assumption that the mean of the three observed years is the mean of the forty-three years considered may be somewhat in error.

The outflow from Lake Erie was measured at International Bridge, Niagara River, from 1898 to 1900. The results are given in the Report of the Chief of Engineers for 1900, pages 5326 et seq. The formula for the discharge of Niagara River derived from these results is as follows:

Discharge in s-f=158,500+22,462(C—570 ft.).

C is the elevation of Lake Erie as herewith given in Table IV.

This formula may require two small corrections: First, the discharge should be increased by the flow through the Welland and Erie canals. The flow through the Welland Canal is is estimated by the department of railways and canals of Canada as 1,100 s-f. The flow through the Erie Canal is estimated by the New York engineer for water supply as 1,200 s-f, making a total of 2,300 s-f. The second correction is due to a difference between the zeros of the gauges at Cleveland and Buffalo. This difference has been observed and determined for calm weather, when it amounts to about 8,500 s-f. For use in this connection the mean for both calm and windy

weather should be known; therefore, on account of the remaining uncertainties in these two corrections, neither of them has been applied. The two corrections are in opposite directions and tend to eliminate each other.

The outflow from Lake Ontario was measured from 1900 to 1902. The resulting formula for the discharge of St. Lawrence River is given on page 2793 of the Report of the Chief of Engineers for 1902, and is as follows:

Discharge in s-f=946833+25761 (0—240 ft.),

in which 0 is the elevation of Lake Ontario at Oswego, as herewith given in Table IX.

It was found that for Lake Ontario there was a small correction, due to ice effects, for the winter months. These corrections are given on page 2809 of the Report of Chief of Engineers for 1902, and are as follows:

Percentage of loss on account of ice:	Per cent.
January	6.2
February	9
March	5.3
April	1.2

These percentages have been computed and subtracted from the discharge, as given by the preceding formula.

In the preceding formula the elevation of lake surface above sea level is expressed in feet, and "s-f" means cubic feet per second.

Discharge measurements are still continued by the lake survey, so that it is probable that the preceding formula will in time be slightly modified, so as to be a little more exact, but no large change is expected or possible.

By means of the preceding formula the discharge tables herewith given (VI to IX) have been derived from the tables of surface elevation herewith given (I to V).

RAINFALL.

The rainfall (which includes snowfall) has been compiled from the records of the United States Weather Bureau and the Canadian meteorological service. The period chosen is the sixteen years from 1882 to 1898. The years before 1882 were not used, because the number of stations where rainfall records were kept were few in number; the four years since 1898 could now be added, and thus increase the value of the result. The stations at which observations were made are shown on Plate I herewith. The Weather Bureau stations

are indicated by special marks; the other stations are volunteer stations. At many of these observations were made for only a part of the time. It will be seen that the stations are quite unsymmetrically placed in the basin, most of them being in the southern part. This is the most serious defect in the rainfall data. Since the rainfall diminishes both to the north and to the west, it is evident that the direct mean of the rainfall as observed at these stations would be greater than the mean rainfall of the whole basin. To avoid this source of error as far as possible two methods of reduction were employed. The first was to prepare a map for each month on which the stations used during that month were plotted in their proper geographical positions; the inches of rainfall at each station were written in figures, then curves of equal rainfall were drawn among the plotted points as contours are drawn. These curves show the regions of equal rainfall; the irregular areas bounded by these curves were then measured with a planimeter and each one multiplied by its rainfall, and a mean of all taken, which was assumed to be the mean rainfall in the basin for that month. This method was applied from 1883 to 1893; it required a great amount of work, and was finally changed to the second method, which was shorter and perhaps equally accurate, as follows:

The Weather Bureau has determined the lines of equal rainfall from all available data and published the results in the form of a map (Plate VII of report for 1897); from this map the rate of change in rainfall due to the change in latitude and longitude was determined for each basin. The mean latitude and longitude of the basins was also found; then the rainfall at each station was corrected by its distance in latitude and longitude from the center of the basin.

The results for the several basins are herewith given in Tables X to XIII, and are as follows:

The mean annual rainfall in—	Inches.
Lake Superior basin	=26.27
Lakes Huron and Michigan basins	=32.12
St. Clair and Erie basins	=34.08
Ontario basin	=36.87

The rainfall records are kept in inches, while the unit of discharge is cubic feet per second, or s-f. In order to compare them with each other it is necessary to express both quantities in the same unit; for this purpose the following table is prepared, which shows the equivalent in s-f of the rainfall in the several basins:

Annual rainfall—	s-f.
Superior basin	=147,164
Huron and Michigan	=325,857
St. Clair and Erie	=102,308
Ontario	= 89,557

EVAPORATION.

It is assumed that if the mean annual discharge or outflow from a basin be subtracted from the mean annual rainfall into the basin the remainder will be the mean annual evaporation. For the basin of Lake Superior the mean annual rainfall from the preceding table is 147,164 s-f. The mean annual discharge for sixteen years (1882-1898) from Table VI herewith is 69,954 s-f; the difference is 77,210 s-f=13.78 inches. There is a small correction to apply to this quantity, due to the fact that Lake Superior was 1.31 inches higher at the end of the period considered than at the beginning; this makes a correction of —0.03 inch, and the evaporation for the Lake Superior basin is 13.75 inches.

For the Huron and Michigan basins the mean annual rainfall from the preceding table is 325,857 s-f. The inflow from St. Marys River from Table VI herewith is 69,954 s-f, making the total inflow 395,811 s-f. The discharge or outflow from Table VII herewith is 191,980 s-f. The difference between the inflow and outflow is, then, 203,831 s-f=20.29 inches.

There is a correction to apply to this quantity, due to the fact that Lakes Huron and Michigan were 22.8 inches lower at the end of the period considered (1882 to 1898) than at the beginning; this makes a correction of +0.47 inch, and the evaporation of the Huron and Michigan basin is 20.56 inches.

For the St. Clair and Erie basin the mean annual rainfall from the preceding table is 102,308 s-f. The inflow from St. Clair River from Table VII herewith is 191,980 s-f, making the total inflow 294,288 s-f. The discharge or outflow from Table VIII herewith is 216,468 s-f. The difference between the inflow and outflow is, then, 77,820 s-f=25.90 inches. There is a correction to apply to this quantity, due to the fact that Lake Erie was 12.30 inches lower at the end of the period than at the beginning; this makes a correction of +0.20 inch, and the evaporation of the St. Clair and Erie basin is 26.10 inches.

For the Ontario basin the mean annual rainfall from the preceding table is 89,557 s-f. The inflow from Niagara River is 216,468 s-f, making the total inflow 306,025 s-f.

The discharge or outflow through the St. Lawrence River from Table IX herewith is 248,518 s-f. The difference between the inflow and outflow is, then, 57,507 s-f=23.67 inches. There is a correction to apply to this quantity, due to the fact that Lake Ontario was 10.56 inches lower at the end of the period than at the beginning; this makes a correction of +0.15 inch, and the evaporation of the Ontario basin is 23.82 inches.

WEATHER BUREAU RECORDS.

Temperature, humidity, and wind, together with rainfall, are the four elements which very largely control evaporation. These have accordingly been compiled from the Weather Bureau records. On account of the unsymmetrical geographical distribution of the stations in the basins, a direct mean of the observations would not give a correct mean for the basin. For use and further reference in connection with this report and discussion, the Weather Bureau observations have therefore been reduced in the same manner as previously described for rainfall, and, as so reduced, are given in Tables X to XXV herewith.

GENERAL RESULT.

The results for each basin are herewith summarized, as follows:

Superior basin.

Area of drainage basin	square miles	76,100
Area of Lake Superior	do	32,100
Discharge St. Marys River (mean 1882-1898)	s-f	69,954
Discharge St. Marys River (mean 1860-1903)	do	77,345
Annual rainfall (mean 1882-1898)	inches	26.27
Annual evaporation (mean 1882-1898)	do	13.75
Temperature (mean 1882-1898)		35°.95 F.
Wind, velocity per hour (mean 1882-1898)	miles	9.7
Humidity, percentage of saturation (mean 1882-1898)	per cent.	76.5

Huron and Michigan basins.

Area of drainage basin	square miles	137,800
Area of Lakes Huron and Michigan	do	45,500
Discharge St. Clair River (mean 1882-1898)	s-f	191,980
Discharge St. Clair River (mean 1860-1902)	do	197,820
Annual rainfall (mean 1882-1898)	inches	32.21
Annual evaporation (mean 1882-1898)	do	20.56
Temperature (mean 1882-1898)		42°.08 F.
Wind, velocity per hour (mean 1882-1898)	miles	10.3
Humidity, percentage of saturation (mean 1882-1898)	per cent.	76.5

St. Clair and Erie basins.

Area of drainage basin	square miles	40,800
Area of Lakes St. Clair and Erie	do	10,600
Discharge Niagara River (mean 1882-1898)	s-f	207,468
Discharge Niagara River (mean 1860-1902)	do	219,843
Annual rainfall (mean 1882-1898)	inches	102.308
Annual evaporation (mean 1882-1898)	do	26.10
Temperature (mean 1882-1898)		48°.01 F.
Wind, velocity per hour (mean 1882-1898)	miles	10.4
Humidity, percentage of saturation (mean 1882-1898)	per cent.	73.6

Ontario Basin.

Area of drainage basin	square miles	33,000
Area of Lake Ontario	do	7,400
Discharge of St. Lawrence River (mean 1882-1898)	s-f	248,518
Discharge of St. Lawrence River (mean 1860-1902)	do	251,930
Annual rainfall (mean 1882-1898)	inches	36.87
Annual evaporation (mean 1882-1898)	do	23.82
Temperature (mean 1882-1898)		44°.10 F.
Wind, velocity per hour	miles	10.6
Humidity, percentage of saturation (mean 1882-1898)	per cent.	74.9

These results are apparently consistent with each other, at least within the limits of the accuracy of the data. Formerly there was a marked inconsistency between the derived discharges of the St. Clair and Niagara and St. Lawrence rivers, the St. Clair being nearly as large as the Niagara, and the St. Lawrence being very much larger than the Niagara. The investigations of ice effects, made by the United States lake survey, has reduced the derived discharge of both the St. Clair and the St. Lawrence rivers, so that now their relation to the derived discharge of the Niagara is entirely reasonable, and there is no longer cause for the theory that a part of the discharge from Lake Erie passes by underground percolation into Lake Ontario.

Very respectfully,

E. S. Wheeler,
Assistant Engineer.

Maj. William H. Bixby,
Corps of Engineers, U. S. Army.

APPENDIX A.

Memoranda prepared July 17, 1900, by Asst. Engineer E. S. Wheeler, for the discussion of the discharge observations made in St. Marys River at Sault Ste. Marie in 1896-1899, under the river and harbor office of Col. G. J. Lydecker, showing the data and methods used in determining formulae for Lake Superior outflow.

Four separate groups of observations were made and two different cross sections used during 1896-1899. In 1896 Mr. E. E. Haskell made 34 measurements at the Spry dock section and 11 measurements at the bridge section. The former were published in the Annual Report of the Chief of Engineers for 1897. In 1899 Mr. T. Russell made 65 measurements at the Spry dock section and 34 at the bridge section.

The measurements at Spry dock section include the entire outflow from Lake Superior; those at the bridge section include only the flow which passes under the bridge. A gauge at the south end of the bridge was read for all four groups. This gauge is in span 1, which is a part of the Chandler-Dunbar canal; its relation to the bowlder gauge was determined by several sets of simultaneous observations, as follows:

Gauge at bridge.	Gauge at bowlder.	Gauge at bridge.	Gauge at bowlder.	Gauge at bridge.	Gauge at bowlder.	Gauge at bridge.	Gauge at bowlder.
Feet.		Feet.		Feet.		Feet.	
601.70	+ .11		.20		.17		.17
.80	.11		.20		.16		.16
.91	.10		.19		.17		.17
.91	.11		.19		.17		.16
601.90	.11		.19		.17		.16
602.00	.11		.19		.16		.16
.00	.11		.19		.16		.16
.10	.11		.18		.16		.16
.17	.11	602.00	.21		.16		.17

The mean of this determination is 0.17 feet; and a comparison of these observations does not indicate any change due to stage. The difference between the gauge at the bowlder and at the bridge was therefore taken as 0.17 feet at all stages, and the bridge gauge readings were increased by this amount, so that in the following discussion all gauge readings have been reduced to and referred to the gauge at the west end of the southwest canal pier.

In order to make the four groups of measurements comparable with each other, the two Spry dock groups were diminished by the amount that was passing outside of the bridge at the time the observations were made. The outside flow was measured in 1896 and found to be 5,000 s-f at stage 601.17, with an increment of 950 s-f for each foot of rise in the gauge. In 1899 the outside flow was found to be 10,768 s-f

at stage 601.17, with the same increment of 950 s-f for each foot of rise in the gauge. The flow under the bridge resulting from such measurements and corrections is as given in the following tables:

[From current measurements made at Spry dock in 1896 by E. E. Haskell.]

Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.
Feet.	*S-f.*	*Feet.*	*S-f.*	*Feet.*	*S-f.*
600.95	a 54,720	601.20	63,020	601.42	68,140
601.02	55,800	.26	63,770	.44	68,330
.07	56,250	.26	63,954	.45	68,205
.07	56,660	.26	64,204	.46	68,045
.09	56,831	.27	63,045	.49	68,430
.10	60,106	.27	63,606	.49	68,946
.21	57,679	.28	63,275	.50	68,260
.25	59,869	.30	63,694	.50	67,096
.28	62,049	.41	64,517	.51	69,207
.28	62,269	.43	63,045	.52	64,467
.27	60,560	.43	63,449	.53	66,888
.27	61,650	.44	63,965	.55	69,450
.28	62,971	.46	63,139	.71	69,452
.28	63,121	.46	64,099	.72	a 64,615
.29	59,863	.46	63,440	.88	69,227
.30	62,971	.47	64,010	.88	71,097
.31	61,045	.47	63,570		
.32	61,255	.51	63,289	601.41	68,980
.32	61,702	.51	62,913	Increment, 17.139.	

a These figures are questionable.

[From current measurements made at Spry dock in 1896 by T. Russell.]

Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.
Feet.	*s-f.*	*Feet.*	*s-f.*	*Feet.*	*s-f.*
600.92	53,897	601.10	58,483	601.19	67,020
.97	53,738	.10	59,031	.19	66,736
.00	54,504	.11	58,519	.19	66,897
.00	55,656	.11	58,703	.19	66,967
.03	54,954	.11	60,809	.20	66,021
.03	54,060	.11	59,805	.20	65,809
.05	55,139	.13	57,897	.20	66,730
.07	55,688	.16	57,758	.21	67,009
.07	53,877	.13	55,046	.23	65,204
.09	55,408	.14	58,090	.23	65,809
601.00	55,440	.14	58,897	.25	65,011
.00	55,881	.14	58,698	.25	65,743
.04	55,730	.15	56,419	.29	69,964
.05	55,660	.15	57,980	.29	64,5297
.06	56,617	.15	56,468	.40	63,560
.08	54,497	.15	57,080	.41	66,729
.08	56,964	.15	66,129	.44	66,075
.08	55,480	.16	56,440	.55	69,7827
.08	55,603	.16	56,996	.57	64,5099
.08	56,287	.17	57,288		
.08	55,965	.17	64,397	601.12	56,986
.08	57,191	.19	59,647	Increment, 15,389.	
.10	54,493	.19	59,586		

[From current measurements made at bridge in 1896 by E. E. Haskell.]

Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.
Feet.	*s-f.*	*Feet.*	*s-f.*	*Feet.*	*s-f.*
601.38	69,540	601.90	69,897	600.98	66,276
.36	69,310	.93	70,510		
.49	70,080	.97	69,943	601.41	77,028
.73	77,028	602.05	69,260	Increment, 10,897.	
.85	79,109	.14	64,408		

[From current measurements made at the bridge in 1899 by T. Russell.]

Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.	Bowlder gauge.	Discharge.
Feet.	*c-f*	*Feet.*	*c-f*	*Feet.*	*c-f*
601.61	68,921	602.26	80,676	602.52	88,326
.69	71,466	.27	80,883	.53	84,210
.86	74,252	.39	80,898	.54	85,722
.95	76,047	.32	81,009	.56	85,213
.98	76,176	.33	82,706	.64	87,599
602.13	78,577	.34	81,950	.64	88,638
.13	77,469	.39	83,106	.65	88,072
.17	79,300	.44	84,914	.67	87,850
.21	79,088	.45	83,850	.67	86,736
.21	81,397	.47	83,297	602.98	97,196
.24	80,483	.49	84,395	602.31	82,194
.25	81,835	.52	85,184	Increment, 16,430.	

These groups have also been discussed and platted separately, the discharge in each case being represented graphically by a straight line.

In their discussions the groups were given different weights due to the number of observations, range in gauge readings, and accuracy of rating, and the discharge at the mean stage was found by giving to each group a weight equal to the product of its rating into the square root of the number of observations.

The relative weight was assigned as follows:

Spry dock:

1896..... 10
1899..... 8

Bridge:

1899..... 3
1896..... 1

The number of observations was as follows:

Spry dock:

1896..... 52
1899..... 62

Bridge:

1899..... 34
1896..... 11

The results of the four groups were then:

	Date.	Gauge.	Discharge.	Weight.
Spry dock	1896	601.41	68,980	10×√52
Do	1899	601.19	86,926	8×√62
Bridge	1899	602.31	82,194	3×√34
Do	1896	601.31	77,669	1×√11

Giving at stage 601.402 a discharge of 63,000 s-f.

The increase in discharge for 1 foot change in gauge was found by giving to each group a weight equal to the product of its rating and range in gauge reading, as follows:

Spry dock:		
1896	17,139	10×10
1899	15,963	8× 7
Bridge:		
1899	16,426	3×17
1896	18,227	1× 9

Giving 16,706 s-f. as the change in discharge for 1 foot change in gauge reading; and at gauge 600, a discharge of 39,578 s-f; and a discharge equation of—

(1) Discharge=39,578+16,706×(gauge —600),

applicable to the discharge under 8 spans of the bridge, not including spans 1 and 2, which are in the Chandler-Dunbar Water Power Canal.

The observations show that the discharge curve may be taken as a linear function of elevation without appreciable error, at least within the small range of elevation used. To obtain the total flow in the river there must be added the flow through the Canadian Water Power, the Chandler-Dunbar Water Power, the two ship canals, and the two small streams on the Canadian side.

The flow through the river before the building of the bridge will first be determined. From a report (with sketches) of Asst. Engineer E. E. Haskell, dated June 11, 1896,* it is found that the building of the bridge and approaches and other works (largely in shallow parts of the river), done between 1887 and 1892, diminished the cross-section of the river (at stage 601.53) 38 per cent. in width and 26.4 per cent. in area, diminished the discharge 14 per cent., and increased the mean velocity 17 per cent. (The sketch which accompanies Mr. Haskell's report shows that the width of the cross-section before 1888 was 4,200 feet and after the obstructions were made was only 2,600 feet.) From this data it is possible to determine the discharge equation before 1888. First, by the preceding equation the discharge is zero at stage 597.63, and therefore (assuming the discharge curve to be a straight line) 597.63 must be the elevation of the bottom of the river. This

*Not published.

therefore there is already one gauge reading, viz, 597.63, at which the discharge before 1888 is known. If now the increment for unit of gauge can be determined the discharge equation will be complete. Since the discharge after obstruction is 14 per cent. less than before, the increment after obstruction must be 14 per cent. less than the increment before. Since the increment after obstruction is 16,706 s-f, it follows that the increment before was 19,429 s-f. Since the discharge is zero at gauge 597.63, the discharge at gauge 600 is 46,047 s-f, and a new discharge equation may be written.

(2) Discharge=46,047+19,429×(gauge—600),
applicable to all gauge readings before 1888.

Between 1888 and 1895 the only outside flow was through two small streams on the Canadian side and through the United States canal. The amount of this flow is estimated as 1,674 s-f at stage 601.53, with an increment of 950 s-f for foot of rise. Adding the corrections to equation (1) there results the following:

(3) Discharge=39,798+17,656×(gauge—600),
applicable to all gauge readings from 1888 to 1895, both years inclusive.

The outside flow from 1896 to 1898 includes the two ship canals, the two water powers, and the two small streams; the total is estimated as 5,000 s-f at stage 601.17 with an increment of 950 s-f for each foot of rise. Adding these amounts to equation (1) there results the following,

(4) Discharge=43,466+17,656×(gauge—600),
applicable to all gauge readings from 1896 to 1898, inclusive.

In 1899 both water powers had been enlarged, and it is estimated that the total outside flow at stage 601.17 was 10,768 with an increment of 950 s-f. Adding these corrections to equation (1) there results,

(5) Discharge=49,235+17,656×(gauge—600),
applicable to gauge readings in 1899 and until further changes are made in the outside flow.

Collecting the equations, the relation between discharge and gauge at southwest canal pier is therefore assumed as follows:

Equation for discharge through eight spans of the bridge,

$$\text{Discharge}=39{,}578+16{,}706\times(\text{gauge}-600) \quad (1)$$

Equation for total discharge before 1888,

$$\text{Discharge}=46{,}047+19{,}429\times(\text{gauge}-600) \quad (2)$$

Equation for total discharge from 1888 to 1895, inclusive,

$$\text{Discharge}=39{,}798+17{,}656\times(\text{gauge}-600) \quad (3)$$

would be equally true before the obstructions were made, and

Equation for total discharge from 1896 to 1898, inclusive,

$$\text{Discharge}=43{,}466+17{,}656\times(\text{gauge}-600) \quad (4)$$

Equation for discharge in 1899 and until further changes are made,

$$\text{Discharge}=49{,}235+17{,}656\times(\text{gauge}-600) \quad (5)$$

TABLE I.—*Showing, in feet, the mean monthly elevation of Lake Superior above locks at St. Marys Falls Canal.*

Date.	January.	February.	March.	April.	May.	June.
1860	601.99	601.74	601.74	602.24	602.47	602.64
1861	602.08	601.70	601.56	601.97	602.00	602.75
1862	601.74	601.55	601.56	601.64	602.32	602.56
1863	601.71	601.58	601.41	601.45	601.56	601.56
1864	601.35	601.15	601.22	601.24	601.40	601.23
1865	601.02	601.01	600.88	601.33	601.81	602.12
1866	601.39	601.38	601.01	601.53	601.78	601.91
1867	601.75	601.64	601.45	601.67	601.67	602.27
1868	601.63	601.04	601.40	601.50	601.99	602.09
1869	601.05	601.41	600.96	601.54	601.94	601.95
1870	601.87	601.65	601.67	601.77	602.10	602.01
1871	601.165	601.002	600.786	600.859	601.446	601.664
1872	600.948	600.884	600.628	600.580	601.469	601.627
1873	601.285	601.109	601.186	601.152	601.709	601.825
1874	601.471	601.314	601.205	601.084	601.501	601.589
1875	601.606	601.448	601.407	601.467	601.961	602.252
1876	601.644	601.502	601.337	601.373	602.107	602.454
1877	601.835	601.660	601.746	601.621	601.935	601.998
1878	601.473	601.316	601.114	601.068	601.373	601.622
1879	600.925	600.435	600.182	600.311	600.695	600.866
1880	600.339	600.293	600.139	600.217	600.957	601.734
Mean	601.422	601.270	601.173	601.329	601.737	601.962

TABLE I.—*Showing, in feet, the mean monthly elevation of Lake Superior above locks at St. Marys Falls Canal*—Continued.

Date.	July.	August.	September.	October.	November.	December.
1860	602.60	602.62	602.65	602.67	602.59	602.54
1861	602.91	602.87	602.78	602.61	602.47	602.49
1862	602.52	602.45	602.37	602.30	602.17	601.90
1863	601.94	602.39	602.25	602.11	601.78	601.65
1864	601.94	601.85	601.80	601.84	601.65	601.50
1865	602.54	602.62	602.61	602.42	601.98	601.52
1866	602.39	602.49	602.52	602.34	602.04	602.02
1867	602.60	602.45	602.56	602.54	602.11	601.79
1868	602.12	602.04	602.17	602.14	602.30	601.87
1869	602.52	602.79	602.69	602.51	602.77	602.19
1870	602.10	602.10	602.27	602.11	601.98	601.00
1871	602.095	601.954	602.005	601.805	601.698	601.190
1872	602.041	602.267	602.420	602.291	602.157	601.962
1873	602.869	602.893	602.895	602.683	602.549	602.067
1874	602.307	602.304	602.265	602.477	602.307	602.180
1875	602.940	602.989	602.945	602.819	602.698	601.673
1876	602.145	602.191	602.225	602.080	602.019	602.120
1877	602.177	602.289	602.095	602.009	601.895	601.699
1878	601.741	601.699	601.415	601.288	601.441	601.289
1879	601.124	601.152	601.075	601.009	600.961	600.888
1880	601.956	601.886	601.901	601.787	601.701	601.517
Mean	602.196	602.262	602.249	602.101	602.012	601.874

Date.	January.	February.	March.	April.	May.	June.
1861	601.199	601.105	601.126	601.011	601.427	601.925
1862	601.489	601.371	601.154	601.103	601.514	601.958
1863	601.145	601.040	601.060	601.128	601.118	601.485
1864	601.131	600.940	600.864	600.664	601.055	601.120
1865	601.247	601.128	600.988	600.982	601.408	601.741
1866	601.004	600.889	600.846	600.988	601.301	601.467
1867	600.945	600.810	600.778	600.661	600.986	601.442
1868	600.945	600.804	600.645	600.695	601.288	602.085
1869	601.288	601.089	601.080	601.005	601.616	601.796
1870	601.804	600.720	600.728	600.687	601.120	601.704
1871	600.668	600.778	600.627	600.501	601.501	601.180
1872	600.515	600.467	600.577	600.430	600.940	601.930
1873	600.669	600.664	600.498	600.649	601.295	601.757
1874	601.095	600.951	600.841	601.288	602.204	602.441
1875	601.801	601.696	601.484	601.442	601.945	602.082
1876	601.468	601.407	601.288	601.280	601.995	602.207
1877	601.722	601.416	601.421	601.287	601.910	602.270
1878	601.189	600.988	600.808	601.089	601.531	601.888
1879	601.028	601.117	601.097	601.051	601.919	602.207
1880	601.977	601.770	601.939	602.084	601.516	601.774
1881	602.097	601.994	601.979	601.707	602.086	602.044
1882	601.74	601.57	601.49	601.56	602.90	602.17
Mean	601.275	601.099	601.028	601.049	601.849	601.933

Date.	July.	August.	September.	October.	November.	December.
1861	601.969	601.790	601.599	602.427	602.324	602.026
1862	601.948	602.097	601.920	601.908	601.940	602.073
1863	601.691	602.086	601.728	601.876	601.499	601.989
1864	601.979	601.417	601.434	601.549	601.677	601.413
1865	602.919	602.148	602.004	601.781	601.649	601.288
1866	602.089	601.773	601.684	601.682	601.886	601.166
1867	601.819	601.744	601.646	601.739	601.560	601.085
1868	602.248	602.227	602.150	602.140	601.941	601.618
1869	602.098	602.070	602.040	601.916	602.017	601.999
1870	602.028	601.974	601.940	602.119	601.926	601.818
1871	602.268	602.274	602.226	601.994	601.146	602.040
1872	601.440	602.451	602.559	601.402	601.128	602.041
1873	602.868	602.098	602.006	601.847	601.799	601.868
1874	602.247	602.201	602.089	602.001	601.438	602.121
1875	602.469	602.427	602.095	602.179	602.256	602.048
1876	602.098	602.140	602.111	601.966	602.015	602.051
1877	602.469	602.284	602.285	602.271	602.197	601.979
1878	601.974	602.098	602.086	602.096	601.997	602.010
1879	602.097	602.719	602.695	602.571	602.412	602.468
1880	602.041	602.248	602.199	602.094	602.079	602.099
1881	602.419	602.284	602.099	602.074	602.119	602.136
1882	602.40	602.26	602.42	602.39	602.36	602.07
Mean	602.093	602.109	602.097	602.087	601.913	601.995

TABLE II.—*Showing, in feet, the mean monthly elevation of Lakes Huron and Michigan at Sand Beach.*

Date.	January.	February.	March.	April.	May.	June.
1860	582.32	582.27	582.41	582.36	582.46	582.47
1861	581.49	581.58	581.66	581.66	581.69	581.69
1862	581.66	581.66	581.62	582.04	582.41	582.51
1863	581.95	581.70	581.65	581.73	582.04	582.01
1864	581.39	581.34	581.34	581.44	581.67	581.81
1865	580.81	580.30	580.47	580.98	581.13	581.31
1866	580.13	579.96	579.93	580.20	580.54	580.77
1867	580.84	580.50	580.77	581.09	581.26	581.47
1868	580.10	580.03	580.74	580.94	581.05	581.19
1869	579.90	579.97	579.71	580.05	580.41	580.61
1870	580.17	580.36	581.16	581.55	581.98	582.17
1871	581.23	581.14	581.74	581.94	582.29	582.51
1872	580.40	580.32	579.79	580.20	580.91	581.19
1873	579.09	579.08	580.13	580.54	581.04	581.31
1874	581.21	581.36	581.49	581.94	581.97	581.97
1875	580.65	580.59	580.65	580.99	581.17	581.31
1876	581.00	581.21	581.34	581.68	582.03	582.13
1877	581.96	581.94	581.97	581.95	582.13	582.23
1878	581.55	581.36	581.56	581.48	581.86	581.97
1879	581.08	580.78	580.74	580.77	580.99	581.19
1880	580.54	580.49	580.47	580.48	580.88	581.07
Mean	580.975	580.889	581.015	581.304	581.589	581.781

Date.	July.	August.	September.	October.	November.	December.
1860	582.78	582.69	582.69	582.11	581.99	581.99
1861	582.84	582.65	582.57	582.73	582.74	582.71
1862	582.51	582.54	582.34	582.09	582.20	582.11
1863	582.05	582.00	581.95	581.99	581.95	581.91
1864	581.89	581.79	581.49	581.27	580.70	580.51
1865	581.60	581.61	581.49	581.25	580.99	580.81
1866	581.11	581.17	581.09	580.91	580.68	580.51
1867	581.74	581.67	581.49	581.07	580.61	580.41
1868	581.16	580.99	580.86	580.65	580.39	580.19
1869	581.38	581.30	581.17	581.11	580.99	580.81
1870	582.17	582.01	582.29	581.99	581.85	581.71
1871	582.38	582.15	581.73	581.38	581.05	580.81
1872	581.10	581.07	580.97	580.85	580.68	580.51
1873	581.64	581.66	581.49	581.45	581.25	581.05
1874	581.59	581.73	581.69	581.38	580.79	580.61
1875	581.47	581.64	581.68	581.49	581.29	581.09
1876	582.13	582.09	582.09	582.06	582.03	581.93
1877	582.34	582.18	581.89	581.75	581.70	581.61
1878	582.09	581.99	581.79	581.71	581.48	581.38
1879	581.09	580.99	580.87	580.69	580.51	580.31
1880	581.07	581.07	581.06	581.10	580.99	580.81
Mean	581.914	581.808	581.709	581.449	581.244	581.059

Date.	January.	February.	March.	April.	May.	June.
1881	580.65	580.61	580.65	580.67	580.89	581.09
1882	581.44	581.42	581.36	581.57	581.74	581.91
1883	581.26	581.17	581.21	581.29	581.79	581.99
1884	582.05	581.99	581.94	582.05	582.17	582.31
1885	581.99	581.97	581.97	581.99	582.09	582.29
1886	582.13	582.09	582.03	582.01	582.04	582.09
1887	581.73	581.64	582.15	582.03	582.09	582.29
1888	580.89	580.74	580.91	581.09	581.49	581.71
1889	580.74	580.69	580.64	580.67	580.73	580.91
1890	580.67	580.15	580.13	580.27	580.58	580.81
1891	580.69	579.95	579.89	580.21	580.46	580.69
1892	579.69	579.48	579.46	579.69	579.89	580.09
1893	579.89	579.68	579.68	579.78	580.07	580.27
1894	579.73	579.73	579.68	580.11	580.51	580.71
1895	579.69	579.69	579.61	579.81	579.99	580.19
1896	579.89	579.77	579.68	579.79	579.99	580.19
1897	579.61	579.59	579.68	579.69	579.87	580.07
1898	579.89	579.83	579.83	580.03	580.13	580.31
1899	579.94	579.91	579.89	579.48	579.68	579.89
1900	579.89	579.79	579.68	579.64	579.69	579.89
1901	579.79	579.61	579.63	580.10	580.31	580.51
1902	579.51	579.31	579.23	579.45	579.69	579.89
Mean	580.367	580.257	579.260	580.474	580.736	580.936

TABLE II.—*Showing, in feet, the mean monthly elevation of Lakes Huron and Michigan at Sand Beach*—Continued.

Date.	July.	August.	September.	October.	November.	December.
[illegible]	581.71	581.54	581.36	581.46	581.76	581.89
[illegible]	582.11	582.17	582.05	581.98	581.87	581.49
[illegible]	582.69	582.69	582.67	582.54	582.25	582.24
[illegible]	582.61	582.49	582.14	582.00	581.69	581.69
[illegible]	582.73	582.55	582.70	582.59	582.39	582.13
[illegible]	582.97	582.88	582.64	582.51	582.24	581.99
[illegible]	582.46	582.25	581.99	581.86	581.59	581.34
581. 66	581.56	581.46	581.27	581.09	580.94
581. 30	581.24	581.07	580.70	580.38	580.23
581. 20	581.20	580.98	580.72	580.52	580.35
580. 43	580.39	580.14	579.77	579.43	579.43
580. 45	580.53	580.38	580.15	580.09	579.85
580. 84	580.70	580.41	580.20	579.97	579.77
580. 98	580.69	580.50	580.26	580.07	579.77
579. 73	579.68	579.50	579.21	579.03	578.58
579. 58	579.57	579.39	579.19	579.05	578.98
580. 39	580.40	580.14	579.79	579.67	579.37
580. 89	580.97	580.06	579.77	579.69	579.39
580. 64	580.55	580.25	579.94	579.80	579.41
580. 11	580.20	580.26	580.26	580.26	580.08
580. 69	580.66	580.39	580.17	579.98	579.69
580. 26	580.32	580.07	579.76	579.66	579.45
Mean	581.178	581.145	580.980	580.720	580.573	580.311

TABLE III.—*Showing, in feet, the mean monthly elevation of Lake St. Clair at St. Clair Flats Canal.*

Date.	June.	July.	August.	September.	October.	November.
[illegible]	577.08	577.00	576.89	576.99	576.87	576.99
[illegible]	577.89	577.13	577.80	577.05	576.89	576.75
[illegible]	577.13	577.14	576.94	576.73	576.67	576.99
[illegible]	576.79	576.66	576.60	576.37	576.06	575.96
[illegible]	576.69	576.26	576.19	575.96	575.80	575.69
[illegible]	575.94	576.10	576.07	576.00	575.77	576.07
[illegible]	576.09	576.00	575.90	575.81	575.70	575.69
[illegible]	576.89	576.94	576.77	576.69	575.69	575.75
[illegible]	576.06	576.06	575.69	576.45	575.15	576.06
[illegible]	575.97	576.09	576.20	576.15	575.96	575.94
[illegible]	576.69	576.69	576.66	576.67	576.66	576.64
[illegible]	576.57	576.67	576.25	576.15	575.69	575.67
[illegible]	575.66	575.61	575.53	575.43	575.39	574.99
[illegible]	575.70	575.84	575.59	575.60	575.75	575.69
[illegible]	575.17	575.24	575.25	575.06	575.09	575.11
[illegible]	575.69	575.15	575.05	575.60	575.73	575.69
[illegible]	577.46	577.49	577.45	576.98	576.65	576.64
[illegible]	576.69	576.47	576.25	575.13	576.05	575.18
[illegible]	576.69	576.74	576.65	576.81	576.13	575.79
[illegible]	575.89	575.91	575.70	575.52	575.57	575.11
[illegible]	576.19	576.29	576.15	576.97	576.73	576.07
Mean	576.59	576.45	576.35	576.15	575.91	575.70

Date.	June.	July.	August.	September.	October.	November.
[illegible]	576.26	576.40	576.29	576.01	575.81	575.89
[illegible]	577.30	577.26	577.25	577.16	576.89	576.11
[illegible]	577.01	577.08	577.09	577.14	576.77	576.69
[illegible]	577.27	577.28	577.08	576.97	576.45	576.76
[illegible]	577.04	576.96	577.05	576.91	576.89	576.86
[illegible]	576.96	576.99	576.87	576.73	576.58	576.32
[illegible]	576.89	576.80	576.69	576.54	576.61	576.69
[illegible]	576.96	576.97	576.17	576.09	575.86	575.89
[illegible]	576.86	576.99	576.85	576.84	576.86	576.97
[illegible]	576.26	576.21	576.07	575.73	576.13	575.49
[illegible]	576.89	576.80	576.69	576.54	576.74	576.80
[illegible]	576.78	576.89	576.85	576.84	576.69	576.70
[illegible]	576.89	576.97	576.87	576.36	576.10	576.69
[illegible]	574.57	574.69	574.69	574.47	574.07	574.79
[illegible]	574.64	574.61	574.57	574.66	574.55	574.79
[illegible]	576.89	576.77	576.84	576.69	574.73	574.65
[illegible]	575.49	575.49	575.34	575.07	574.61	574.73
[illegible]	575.89	575.49	575.32	575.08	574.79	574.69
[illegible]	575.09	575.17	575.09	575.10	574.94	574.99
[illegible]	574.97	575.26	575.16	575.16	574.84	574.36
[illegible]	576.01	575.64	575.50	575.15	575.11	574.89
Mean	576.89	576.01	575.92	575.70	575.40	575.17

TABLE IV.— *Showing, in feet, the mean monthly elevation of Lake Erie at Cleveland.*

Date.	January.	February.	March.	April.	May.	June.
1860	573.35	573.90	573.89	574.00	574.20	574.27
1861	572.70	572.42	572.08	573.90	574.23	574.09
1862	573.55	573.53	573.37	574.27	574.51	574.52
1863	573.55	573.34	573.78	573.90	574.08	574.00
1864	573.16	573.23	573.54	573.04	573.74	573.69
1865	572.10	571.89	571.94	572.50	573.14	573.12
1866	571.97	571.71	572.10	572.66	572.90	573.16
1867	572.49	572.01	572.51	572.98	573.38	573.46
1868	571.51	571.13	571.79	572.55	573.00	573.09
1869	571.74	571.67	572.15	572.45	573.00	573.19
1870	572.90	572.81	572.98	573.62	573.94	573.97
1871	573.04	572.81	573.09	573.14	573.41	573.42
1872	571.67	571.43	571.94	571.54	571.96	572.08
1873	571.26	571.26	571.20	572.61	573.28	573.42
1874	573.14	573.19	573.32	573.39	573.46	573.52
1875	571.90	571.49	571.65	572.03	573.00	573.19
1876	573.46	573.01	573.66	574.13	574.30	574.32
1877	573.04	572.98	573.45	573.59	573.13	573.15
1878	572.91	573.05	573.16	573.60	573.86	573.97
1879	573.90	573.96	573.49	573.85	573.00	573.09
1880	573.63	573.67	573.83	573.97	573.94	573.93
Mean	573.459	573.357	573.566	573.699	573.456	573.55

Date.	July.	August.	September.	October.	November.	December.
1860	574.01	573.95	573.81	573.21	573.13	573.08
1861	574.15	574.19	574.01	573.79	573.76	573.73
1862	574.45	574.10	573.79	573.41	573.07	573.01
1863	573.98	573.74	573.35	573.01	573.50	573.47
1864	573.43	573.16	573.04	573.03	573.46	573.39
1865	573.03	573.00	573.06	573.05	573.30	573.14
1866	573.37	573.03	573.05	573.05	573.71	573.71
1867	573.47	573.16	573.77	573.43	573.03	573.11
1868	573.08	573.04	573.57	573.13	573.06	573.10
1869	573.67	573.57	573.30	573.05	573.30	573.34
1870	573.95	573.80	573.55	573.17	573.07	573.05
1871	573.48	573.21	573.04	573.27	573.19	573.15
1872	573.04	573.21	573.06	573.01	573.54	573.56
1873	573.94	573.98	573.88	573.59	573.26	573.25
1874	573.56	573.48	573.06	573.62	573.10	573.09
1875	573.06	573.05	573.01	573.48	573.27	573.29
1876	574.50	574.20	574.03	573.50	573.56	573.51
1877	573.45	573.31	573.23	573.53	573.75	573.69
1878	573.96	573.69	573.49	573.14	573.24	573.23
1879	573.19	573.20	573.27	573.24	573.27	573.13
1880	573.44	573.20	573.07	573.03	573.45	573.11
Mean	573.657	573.377	573.136	573.774	573.351	573.31

Date.	January.	February.	March.	April.	May.	June.
1881	571.70	571.51	572.13	573.03	573.35	573.45
1882	573.20	573.10	573.45	573.67	574.07	574.08
1883	572.97	573.09	573.77	573.39	573.35	573.40
1884	573.56	573.14	573.39	573.35	574.13	574.09
1885	573.26	573.15	573.01	573.03	573.50	573.50
1886	573.64	573.61	573.72	573.63	573.30	573.29
1887	573.70	573.13	573.01	573.06	574.14	574.15
1888	573.26	573.09	573.19	573.03	573.07	573.05
1889	573.40	573.24	573.05	573.43	573.61	573.61
1890	573.47	573.70	573.56	573.37	573.71	573.69
1891	573.40	573.33	573.24	573.72	573.53	573.53
1892	571.49	571.10	571.33	571.79	573.59	573.61
1893	571.26	571.24	571.56	573.20	573.13	573.14
1894	571.23	571.51	571.54	573.24	573.60	573.61
1895	571.28	571.09	571.10	571.35	571.57	571.57
1896	571.05	570.97	570.98	571.37	571.75	571.75
1897	571.18	571.26	571.76	573.00	573.68	573.70
1898	571.68	571.58	572.14	573.73	573.87	573.90
1899	571.76	571.55	571.98	573.38	573.53	573.55
1900	571.43	571.68	573.01	573.38	573.46	573.47
1901	571.44	571.09	570.97	571.38	571.40	571.39
1902	571.17	570.79	571.04	571.56	571.95	571.93
Mean	573.01	571.98	572.14	573.56	573.90	573.91

TABLE IV.—*Showing, in feet, the mean monthly elevation of Lake Erie at Cleveland*—Continued.

Date.	July.	August.	September.	October.	November.	December.
[illegible]	573.42	573.10	573.75	573.70	572.84	573.73
[illegible]	574.15	574.01	573.74	573.29	572.97	573.46
[illegible]	574.26	574.19	573.90	573.56	573.19	573.21
[illegible]	574.01	573.85	573.42	573.09	572.61	572.54
[illegible]	574.09	574.04	573.89	573.72	573.57	573.69
[illegible]	573.96	573.76	573.53	573.30	573.01	573.09
[illegible]	573.90	573.61	573.26	572.79	572.69	572.54
[illegible]	573.25	573.25	573.01	573.44	573.20	572.96
[illegible]	573.24	573.09	572.64	572.12	571.96	572.11
[illegible]	573.70	573.28	573.07	573.00	572.76	573.09
[illegible]	573.57	573.39	573.13	572.74	571.30	571.37
[illegible]	573.47	573.13	572.80	572.54	571.91	571.64
[illegible]	573.04	572.70	572.28	571.97	571.57	571.65
[illegible]	573.09	572.45	572.20	571.96	571.73	571.65
[illegible]	571.35	571.47	571.37	570.89	570.79	570.95
[illegible]	571.90	572.11	571.79	571.65	571.13	571.31
[illegible]	573.73	573.56	573.28	573.79	571.96	571.69
[illegible]	573.66	573.46	573.10	571.90	571.79	571.61
[illegible]	573.57	573.19	571.94	571.70	571.71	571.49
[illegible]	573.43	573.40	573.05	571.84	571.59	571.54
[illegible]	573.00	571.97	571.90	571.43	571.35	571.29
[illegible]	573.03	573.51	573.47	573.36	573.11	571.91
Mean	573.11	573.05	573.05	573.29	572.10	572.05

TABLE V.—*Showing, in feet, the mean monthly elevation of Lake Ontario at Oswego.*

Date.	January.	February.	March.	April.	May.	June.
[illegible]	246.67	246.81	246.96	246.89	247.12	247.06
[illegible]	246.58	246.69	247.11	247.03	246.77	246.63
[illegible]	247.20	246.78	247.27	246.17	245.97	246.71
[illegible]	246.78	246.62	247.00	247.73	246.19	246.07
[illegible]	246.43	246.38	246.38	246.58	247.01	246.51
[illegible]	247.17	247.39	247.47	247.15	247.71	247.75
[illegible]	246.65	246.69	246.97	246.65	246.13	246.01
[illegible]	246.04	246.01	246.71	247.01	246.20	246.37
[illegible]	244.60	244.70	244.97	246.61	246.21	246.09
[illegible]	246.31	246.43	246.66	246.19	246.84	247.06
[illegible]	247.05	247.50	247.30	246.44	249.04	248.72
[illegible]	246.15	246.66	246.19	246.79	247.22	247.15
[illegible]	244.68	244.60	244.44	244.68	246.05	246.36
[illegible]	244.40	244.47	244.59	246.63	247.00	247.01
[illegible]	246.44	246.84	247.30	247.38	247.36	247.35
[illegible]	244.68	244.47	244.73	246.68	246.60	246.66
[illegible]	246.40	246.08	246.61	247.30	246.17	246.30
[illegible]	246.98	246.71	246.66	246.65	246.68	246.38
[illegible]	246.67	246.79	246.48	246.73	247.07	247.06
[illegible]	246.90	246.84	246.89	246.80	246.98	246.98
[illegible]	246.41	246.09	246.68	246.91	246.98	246.40
Mean	246.280	246.094	246.346	246.980	247.344	247.280

Date.	July.	August.	September.	October.	November.	December.
[illegible]	247.91	247.85	246.56	246.78	246.84	246.80
[illegible]	246.43	246.28	247.09	247.20	247.31	247.70
[illegible]	246.80	246.86	247.78	247.17	246.98	246.72
[illegible]	247.08	247.40	247.08	246.89	246.66	246.68
[illegible]	247.09	247.42	246.90	246.67	246.54	246.74
[illegible]	247.09	246.98	246.98	246.38	246.91	246.75
[illegible]	246.98	246.89	246.74	246.81	246.37	246.89
[illegible]	246.89	247.37	247.07	246.49	246.68	246.68
[illegible]	246.83	246.89	246.98	246.44	246.89	246.49
[illegible]	247.08	247.44	247.28	247.17	246.77	246.93
[illegible]	246.49	246.89	247.27	247.04	246.67	246.89
[illegible]	246.89	246.89	246.81	246.71	246.68	246.50
[illegible]	246.44	246.89	246.89	246.89	246.72	246.44
[illegible]	246.67	246.89	246.87	246.89	246.89	246.83
[illegible]	246.89	247.17	246.49	246.89	246.46	246.12
[illegible]	246.89	246.89	246.84	246.89	246.17	246.89
[illegible]	246.89	246.89	247.09	247.05	246.89	246.83
[illegible]	246.89	246.89	246.89	246.89	246.84	246.87
[illegible]	247.09	246.96	246.89	246.49	246.20	247.11
[illegible]	246.78	246.89	246.89	246.55	246.12	246.19
[illegible]	246.61	246.19	246.81	246.40	246.89	246.19
Mean	247.288	247.093	246.986	246.874	246.680	246.697

TABLE V.—*Showing, in feet, the mean monthly elevation of Lake Ontario at Oswego*—Continued.

Date.	January.	February.	March.	April.	May.	June.
1861	244.88	244.98	245.42	245.93	246.05	245.9
1862	245.68	245.69	245.98	246.08	247.11	247.0
1863	246.41	246.47	246.71	246.98	246.98	246.8
1864	246.93	246.97	247.06	246.98	247.15	247.0
1865	246.98	246.98	246.98	246.98	247.15	247.0
1866	247.08	247.19	247.36	246.98	246.79	246.7
1867	246.98	247.08	247.08	246.98	246.79	246.7
1868	246.98	246.98	246.98	246.98	246.79	246.7
1869	246.71	246.98	246.98	246.98	246.41	246.3
1870	246.24	246.98	247.08	246.98	247.08	246.9
1871	246.98	246.98	247.08	246.98	246.98	246.8
1872	246.98	246.98	246.98	246.98	246.98	246.8
1873	246.98	246.98	246.98	246.98	246.98	246.8
1874	246.98	246.98	246.98	246.98	246.98	246.8
1875	246.98	246.98	246.98	246.98	246.98	246.8
1876	246.98	246.98	246.98	246.98	246.98	246.8
1877	246.98	246.98	246.98	246.98	246.98	246.8
1878	246.98	246.98	246.98	246.98	246.98	246.8
1879	246.98	246.98	246.98	246.98	246.98	246.8
1880	246.98	246.98	246.98	246.98	246.98	246.8
1881	246.98	246.98	246.98	246.98	246.98	246.8
1882	246.98	246.98	246.98	246.98	246.98	246.8
1883	246.98	246.98	246.98	246.98	246.98	246.8
1884	246.98	246.98	246.98	246.98	246.98	246.8
1885	246.98	246.98	246.98	246.98	246.98	246.8
1886	246.98	246.98	246.98	246.98	246.98	246.8
1887	246.98	246.98	246.98	246.98	246.98	246.8
1888	246.98	246.98	246.98	246.98	246.98	246.8
1889	246.98	246.98	246.98	246.98	246.98	246.8
1890	246.98	246.98	246.98	246.98	246.98	246.8
1891	246.98	246.98	246.98	246.98	246.98	246.8
1892	246.98	246.98	246.98	246.98	246.98	246.8
1893	246.98	246.98	246.98	246.98	246.98	246.8
1894	246.98	246.98	246.98	246.98	246.98	246.8
1895	246.98	246.98	246.98	246.98	246.98	246.8
1896	246.98	246.98	246.98	246.98	246.98	246.8
1897	246.98	246.98	246.98	246.98	246.98	246.8
1898	246.98	246.98	246.98	246.98	246.98	246.8
1899	246.98	246.98	246.98	246.98	246.98	246.8
1900	246.98	246.98	246.98	246.98	246.98	246.8
Mean	246.980	246.988	246.998	246.978	246.980	246.9

Date.	July.	August.	September.	October.	November.	December.
1861	246.87	246.83	246.69	246.64	246.67	246.6
1862	247.01	247.03	246.98	246.98	246.98	246.9
1863	246.71	246.64	246.61	246.61	246.61	246.6
1864	246.93	246.93	246.71	246.98	246.98	246.9
1865	246.98	246.98	246.98	246.98	246.98	246.9
1866	246.98	246.98	246.98	247.11	247.08	247.0
1867	246.98	246.98	246.98	246.98	246.98	246.9
1868	246.98	246.98	246.98	246.98	246.98	246.9
1869	246.98	246.98	246.98	246.98	246.98	246.9
1870	246.98	246.98	246.98	246.98	246.98	246.9
1871	246.98	246.98	246.98	246.98	246.98	246.9
1872	246.98	246.98	246.98	246.98	246.98	246.9
1873	246.98	246.98	246.98	246.98	246.98	246.9
1874	246.98	246.98	246.98	246.98	246.98	246.9
1875	246.98	246.98	246.98	246.98	246.98	246.9
1876	246.98	246.98	246.98	246.98	246.98	246.9
1877	246.98	246.98	246.98	246.98	246.98	246.9
1878	246.98	246.98	246.98	246.98	246.98	246.9
1879	246.98	246.98	246.98	246.98	246.98	246.9
1880	246.98	246.98	246.98	246.98	246.98	246.9
1881	246.98	246.98	246.98	246.98	246.98	246.9
1882	246.98	246.98	246.98	246.98	246.98	246.9
1883	246.98	246.98	246.98	246.98	246.98	246.9
1884	246.98	246.98	246.98	246.98	246.98	246.9
1885	246.98	246.98	246.98	246.98	246.98	246.9
1886	246.98	246.98	246.98	246.98	246.98	246.9
1887	246.98	246.98	246.98	246.98	246.98	246.9
1888	246.98	246.98	246.98	246.98	246.98	246.9
1889	246.98	246.98	246.98	246.98	246.98	246.9
1890	246.98	246.98	246.98	246.98	246.98	246.9
1891	246.98	246.98	246.98	246.98	246.98	246.9
1892	246.98	246.98	246.98	246.98	246.98	246.9
1893	246.98	246.98	246.98	246.98	246.98	246.9
1894	246.98	246.98	246.98	246.98	246.98	246.9
1895	246.98	246.98	246.98	246.98	246.98	246.9
1896	246.98	246.98	246.98	246.98	246.98	246.9
1897	246.98	246.98	246.98	246.98	246.98	246.9
1898	246.98	246.98	246.98	246.98	246.98	246.9
1899	246.98	246.98	246.98	246.98	246.98	246.9
1900	246.98	246.98	246.98	246.98	246.98	246.9
Mean	246.980	246.980	246.980	246.980	246.980	246.9

TABLE VI.—*Showing, in c-f, the mean monthly discharge of St. Marys River*

Date.	January.	February.	March.	April.	May.	June.
1860	56,711	58,000	72,000	72,000	72,000	72,0
1861	58,000	58,000	72,000	72,000	72,000	72,0
1862	58,000	58,000	72,000	72,000	72,000	72,0
1863	58,000	58,000	72,000	72,000	72,000	72,0
1864	58,000	58,000	72,000	72,000	72,000	72,0
1865	58,000	58,000	72,000	72,000	72,000	72,0
1866	58,000	58,000	72,000	72,000	72,000	72,0
1867	58,000	58,000	72,000	72,000	72,000	72,0
1868	58,000	58,000	72,000	72,000	72,000	72,0
1869	58,000	58,000	72,000	72,000	72,000	72,0
1870	58,000	58,000	72,000	72,000	72,000	72,0
1871	58,000	58,000	72,000	72,000	72,000	72,0
1872	58,000	58,000	72,000	72,000	72,000	72,0
1873	58,000	58,000	72,000	72,000	72,000	72,0
1874	58,000	58,000	72,000	72,000	72,000	72,0
1875	58,000	58,000	72,000	72,000	72,000	72,0
1876	58,000	58,000	72,000	72,000	72,000	72,0
1877	58,000	58,000	72,000	72,000	72,000	72,0
1878	58,000	58,000	72,000	72,000	72,000	72,0
1879	58,000	58,000	72,000	72,000	72,000	72,0
1880	58,000	58,000	72,000	72,000	72,000	72,0
1881	58,000	58,000	72,000	72,000	72,000	72,0
1882	58,000	58,000	72,000	72,000	72,000	72,0
1883	58,000	58,000	72,000	72,000	72,000	72,0
1884	58,000	58,000	72,000	72,000	72,000	72,0
1885	58,000	58,000	72,000	72,000	72,000	72,0
1886	58,000	58,000	72,000	72,000	72,000	72,0
1887	58,000	58,000	72,000	72,000	72,000	72,0
1888	58,000	58,000	72,000	72,000	72,000	72,0
1889	58,000	58,000	72,000	72,000	72,000	72,0
1890	58,000	58,000	72,000	72,000	72,000	72,0
1891	58,000	58,000	72,000	72,000	72,000	72,0
1892	58,000	58,000	72,000	72,000	72,000	72,0
1893	58,000	58,000	72,000	72,000	72,000	72,0
1894	58,000	58,000	72,000	72,000	72,000	72,0
1895	58,000	58,000	72,000	72,000	72,000	72,0
1896	58,000	58,000	72,000	72,000	72,000	72,0
1897	58,000	58,000	72,000	72,000	72,000	72,0
1898	58,000	58,000	72,000	72,000	72,000	72,0
1899	58,000	58,000	72,000	72,000	72,000	72,0
1900	58,000	58,000	72,000	72,000	72,000	72,0
Mean	58,000	58,000	72,000	72,000	72,000	72,0

TABLE VI.—*Showing, in a-f, the mean monthly discharge of St. Marys River*—Continued.

Date.	July.	August.	September.	October.	November.	December.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	89,760	90,577	91,659	90,960	85,130	78,577

Date.	January.	February.	March.	April.	May.	June.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	67,180	62,790	62,890	68,972	71,980	78,714

Date.	July.	August.	September.	October.	November.	December.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	88,894	88,980	81,980	81,489	79,944	78,799

Mean discharge from 1860 to 1902 = 77,943 S.-F. Mean discharge from November, 1901, to October, 1902, inclusive, = 80,824 S.-F.

TABLE VII.—*Showing, in c-f, the mean monthly discharge of St. Clair River.*

Date.	January.	February.	March.	April.	May.	June.
1860	197,260	177,228	185,125	200,712	223,216	233,420
1861	181,240	168,038	170,840	193,808	221,169	228,264
1862	188,233	170,668	174,060	194,282	220,264	227,271
1863	186,411	168,469	170,649	188,188	214,783	241,648
1864	177,547	157,702	162,694	185,706	219,648	230,726
1865	187,159	169,736	168,159	173,646	205,947	217,264
1866	156,437	151,780	157,668	182,583	194,574	207,660
1867	169,449	148,319	159,676	175,564	205,997	225,057
1868	185,056	165,211	162,304	167,548	201,435	214,139
1869	151,944	135,486	139,673	156,875	191,715	208,459
1870	157,689	150,489	161,310	185,466	220,495	228,779
1871	161,921	141,323	177,866	197,564	229,075	249,941
1872	168,209	139,404	142,440	160,162	195,599	218,693
1873	164,982	135,211	141,676	165,643	203,722	224,645
1874	176,218	159,736	167,599	180,890	210,993	224,899
1875	168,539	145,312	151,936	170,979	208,303	230,216
1876	170,294	157,130	164,740	186,227	228,319	245,117
1877	190,317	171,043	174,843	196,517	224,307	246,138
1878	182,683	160,270	168,743	183,569	219,720	239,854
1879	173,891	146,904	152,804	170,086	201,054	195,979
1880	168,449	143,216	148,156	164,490	200,073	221,686
Mean	171,965	152,047	159,111	178,606	213,149	230,048

Date.	July.	August.	September.	October.	November.	December.
1860	258,672	257,168	254,195	245,166	242,295	230,280
1861	246,574	235,585	264,617	259,841	250,646	234,611
1862	240,080	251,510	247,400	258,986	252,099	213,206
1863	239,308	240,257	239,301	234,941	237,059	197,104
1864	234,905	232,516	225,938	212,471	208,794	188,542
1865	230,849	231,797	228,500	223,697	209,697	196,373
1866	214,305	218,257	214,316	211,078	210,309	191,288
1867	231,984	228,301	227,224	220,153	210,217	186,300
1868	218,268	209,284	204,209	200,267	200,190	199,858
1869	217,249	220,244	225,135	217,925	216,051	205,694
1870	241,781	239,468	245,738	236,786	227,190	196,699
1871	251,019	245,265	236,090	225,449	220,580	191,256
1872	224,570	220,979	219,939	215,519	213,125	208,911
1873	229,544	220,507	222,264	221,065	221,191	208,089
1874	257,847	254,966	252,070	236,191	211,226	207,497
1875	231,267	232,248	237,500	226,417	224,622	228,984
1876	261,035	262,589	256,889	257,788	254,105	217,749
1877	246,916	246,914	241,359	237,407	233,264	211,429
1878	237,736	235,371	230,284	224,719	223,552	195,649
1879	214,220	213,689	213,267	207,563	207,791	201,127
1880	220,316	223,995	222,080	218,980	217,888	216,675
Mean	236,495	235,976	233,787	229,071	225,300	205,841

Date.	January.	February.	March.	April.	May.	June.
1881	195,239	183,889	189,213	173,744	210,366	226,702
1882	180,993	167,130	164,921	185,874	217,064	228,175
1883	176,453	166,207	168,208	178,408	215,017	227,457
1884	187,980	170,251	176,176	186,285	220,273	244,778
1885	180,870	169,709	174,843	185,080	220,366	224,103
1886	184,220	170,871	165,988	177,036	241,340	272,408
1887	195,845	171,648	160,179	194,634	220,276	247,650
1888	180,670	168,171	166,148	178,888	212,289	240,313
1889	187,864	168,647	161,888	183,214	197,450	224,400
1890	191,888	172,888	161,888	183,888	194,888	216,888
1891	188,888	172,888	161,888	183,888	194,877	216,888
1892	187,888	172,888	161,888	183,888	194,840	216,888
1893	187,888	172,888	161,888	183,888	194,888	216,888
1894	187,888	172,888	161,888	183,888	194,888	216,888
1895	187,888	172,888	161,888	183,888	194,888	216,888
1896	187,888	172,888	161,888	183,888	194,888	216,888
1897	187,888	172,888	161,888	183,888	194,888	216,888
1898	187,888	172,888	161,888	183,888	194,888	216,888
1899	187,888	172,888	161,888	183,888	194,888	216,888
1900	187,888	172,888	161,888	183,888	194,888	216,888
Mean	189,296	169,999	164,797	184,288	206,888	224,888

Date.	July.	August.	September.	October.	November.	December.
1881	240,888	240,888	240,888	240,888	240,888	240,888
1882	240,888	240,888	240,888	240,888	240,888	240,888
1883	240,888	240,888	240,888	240,888	240,888	240,888
1884	240,888	240,888	240,888	240,888	240,888	240,888
1885	240,888	240,888	240,888	240,888	240,888	240,888
1886	240,888	240,888	240,888	240,888	240,888	240,888
1887	240,888	240,888	240,888	240,888	240,888	240,888
1888	240,888	240,888	240,888	240,888	240,888	240,888
1889	240,888	240,888	240,888	240,888	240,888	240,888
1890	240,888	240,888	240,888	240,888	240,888	240,888
1891	240,888	240,888	240,888	240,888	240,888	240,888
1892	240,888	240,888	240,888	240,888	240,888	240,888
1893	240,888	240,888	240,888	240,888	240,888	240,888
1894	240,888	240,888	240,888	240,888	240,888	240,888
1895	240,888	240,888	240,888	240,888	240,888	240,888
1896	240,888	240,888	240,888	240,888	240,888	240,888
1897	240,888	240,888	240,888	240,888	240,888	240,888
1898	240,888	240,888	240,888	240,888	240,888	240,888
1899	240,888	240,888	240,888	240,888	240,888	240,888
1900	240,888	240,888	240,888	240,888	240,888	240,888
Mean	240,888	240,888	240,888	240,888	240,888	240,888

TABLE VII.—*Showing, in s—f, the mean monthly discharge of St. Clair River*—Continued.

Date.	July.	August.	September.	October.	November.	December.
1891	229,625	224,720	224,342	227,245	240,220	212,225
1892	227,558	220,259	220,495	225,766	229,631	226,694
1893	242,209	232,288	245,565	242,876	254,975	218,511
1894	245,809	247,553	240,289	250,050	244,430	227,470
1895	227,995	221,054	221,570	227,705	251,248	222,805
1896	226,209	226,772	225,740	224,799	252,794	224,216
1897	250,560	245,987	237,230	236,874	225,260	220,073
1898	226,169	220,279	220,494	220,569	222,205	190,119
1899	231,576	221,260	219,269	212,540	204,740	190,488
1900	213,260	216,189	212,425	208,466	201,508	174,804
1901	201,371	199,031	194,270	186,809	179,804	179,205
1902	182,859	180,985	194,538	194,777	189,440	161,916
1903	207,800	205,944	199,067	196,436	186,575	161,916
1904	214,569	206,151	203,688	199,270	195,511	160,205
1905	195,958	194,289	181,440	177,851	166,956	165,926
1906	176,567	175,097	174,056	166,515	171,401	174,288
1907	190,737	189,808	194,510	187,883	186,479	186,199
1908	193,274	194,789	189,494	185,262	189,413	176,807
1909	205,600	204,805	203,305	199,430	189,800	189,681
1910	191,765	194,240	189,409	200,060	202,190	172,976
1911	209,585	212,215	202,070	196,936	198,178	178,679
1912	189,660	189,700	190,085	179,730	181,760	189,695
Mean	216,646	217,068	217,869	210,689	207,888	191,042

Mean discharge from 1890 to 1902 = 197,880 S-F. Mean discharge from November, 1902, to October, 1906, inclusive, = 191,960 S-F.

TABLE VIII.—*Showing, in s-f, the mean monthly discharge of Niagara River.*

Date.	January.	February.	March.	April.	May.	June.
1890	208,748	205,951	224,648	240,270	256,097	254,412
1891	219,147	212,958	228,741	246,108	253,760	257,288
1892	227,598	221,058	224,197	254,415	252,804	256,804
1893	230,240	244,734	243,478	245,109	252,148	247,000
1894	207,467	210,895	215,582	235,704	242,838	241,285
1895	205,970	198,648	199,280	216,009	230,051	229,551
1896	200,204	198,910	208,670	216,698	229,640	230,480
1897	212,088	208,649	214,280	225,097	232,748	240,711
1898	198,418	198,888	197,126	215,779	232,168	234,648
1899	197,584	198,019	208,728	215,629	232,098	234,040
1900	205,497	200,620	205,427	220,081	244,734	244,040
1901	215,552	208,141	210,242	220,081	244,095	233,788
1902	198,012	198,651	198,588	220,081	238,973	231,288
1903	196,577	198,805	198,274	217,159	238,773	233,979
1904	200,081	200,154	203,588	224,049	238,773	233,949
1905	195,797	191,986	198,113	204,089	214,695	220,214
1906	212,539	208,111	240,711	220,081	238,973	233,080
1907	208,209	213,696	212,288	220,081	238,973	233,949
1908	208,084	207,059	208,588	220,081	238,973	233,949
1909	220,901	212,797	214,280	220,081	238,973	233,949
1910	217,873	216,474	221,616	226,210	231,977	238,747
Mean	212,714	211,280	216,270	229,198	238,198	235,496

Date.	July.	August.	September.	October.	November.	December.
1890	240,273	244,279	227,242	220,096	226,231	224,960
1891	241,717	238,619	240,272	242,408	245,287	237,711
1892	229,120	230,584	240,272	238,068	237,488	236,120
1893	244,218	242,218	240,716	238,264	234,488	232,221
1894	240,445	238,218	240,272	237,873	238,787	215,889
1895	237,683	238,218	240,272	238,249	230,718	238,889
1896	241,263	238,218	240,272	234,788	215,273	229,887
1897	240,445	238,218	240,272	238,068	231,248	238,889
1898	240,273	238,218	240,272	238,119	228,280	197,218
1899	240,273	238,218	240,272	238,517	232,154	230,048
1900	240,273	238,218	240,272	238,068	237,488	230,279
1901	241,263	240,272	240,272	238,068	237,488	197,218
1902	238,120	238,218	240,272	238,068	237,488	196,284
1903	241,263	240,272	240,272	238,068	237,488	230,279
1904	238,514	238,218	240,272	238,068	237,488	230,279
1905	237,683	238,218	240,272	238,068	237,488	230,279
1906	238,120	238,218	240,272	238,068	237,488	230,279
1907	238,120	238,218	240,272	238,068	237,488	230,279
1908	238,120	238,218	240,272	238,068	237,488	230,279
1909	238,120	238,218	240,272	238,068	237,488	230,279
1910	238,120	238,218	240,272	238,068	237,488	230,279
1911	238,120	238,218	240,272	238,068	237,488	230,279
1912	238,120	238,218	240,272	238,068	237,488	230,279
Mean	239,401	238,869	239,956	239,614	235,241	218,899

TABLE VIII.—*Showing, in s-f, the mean monthly discharge of Niagara River*—Continued.

Date.	January.	February.	March.	April.	May.	June.
1903	196,026	199,156	206,844	222,097	221,052	220,4
1904	200,270	201,272	200,698	244,436	240,220	227,9
1905	211,720	214,448	220,720	228,415	230,746	219,0
1906	208,191	208,022	208,224	245,659	251,717	236,0
1907	211,510	213,720	220,640	228,087	230,465	240,0
1908	240,200	239,624	219,597	229,280	246,102	241,2
1909	213,147	220,810	246,288	247,480	251,488	241,9
1910	211,550	208,446	207,888	221,648	227,424	228,0
1911	212,420	209,515	206,221	213,055	217,086	208,1
1912	213,901	209,492	208,191	224,197	241,524	234,1
1913	218,400	211,920	208,288	219,573	218,189	214,0
1914	199,947	198,219	198,126	198,707	216,977	208,1
1915	196,828	196,460	198,541	209,940	220,908	208,0
1916	203,888	199,184	198,660	208,516	217,576	208,9
1917	196,150	196,941	198,225	199,894	199,786	196,7
1918	196,086	199,899	179,165	189,273	197,889	196,0
1919	196,035	199,489	197,809	210,169	211,576	196,1
1920	196,284	200,739	198,589	220,897	220,618	208,4
1921	205,020	196,216	201,697	208,288	215,289	215,0
1922	191,070	195,707	208,649	210,615	214,276	214,0
1923	200,845	196,264	199,288	199,456	199,158	196,4
1924	194,781	174,670	181,980	196,980	208,201	203,1
Mean	208,548	205,477	205,477	216,448	224,110	220,9

Date.	July.	August.	September.	October.	November.	December.
1903	220,220	220,128	220,970	219,147	215,104	210,0
1904	227,717	242,270	242,209	238,400	230,212	224,1
1905	220,084	220,616	240,208	230,446	224,020	220,0
1906	245,223	244,270	238,220	237,208	227,084	224,0
1907	240,080	240,240	240,277	242,621	240,[illegible]	228,2
1908	247,200	240,456	237,781	232,088	226,111	224,0
1909	242,770	239,240	234,488	231,160	216,104	218,0
1910	228,740	222,502	221,620	218,207	214,025	211,0
1911	207,277	206,254	205,508	208,110	210,020	208,0
1912	231,020	232,720	227,468	228,791	222,517	217,0
1913	216,287	210,140	208,110	197,204	197,701	196,0
1914	208,445	208,251	208,894	206,025	201,440	196,0
1915	224,754	218,147	210,613	208,720	196,746	196,0
1916	221,949	218,222	209,712	208,228	197,126	196,0
1917	196,216	197,539	199,203	199,466	196,240	196,0
1918	196,120	196,262	196,707	196,228	196,020	196,0
1919	220,287	216,020	209,713	196,707	196,791	196,0
1920	224,088	224,201	222,670	221,179	196,464	196,0
1921	211,748	207,487	202,070	196,668	196,010	196,0
1922	212,080	210,450	208,221	196,220	196,220	196,0
1923	196,464	196,264	196,988	196,228	196,227	196,0
1924	208,087	202,456	212,982	211,963	208,885	204,0
Mean	220,277	218,294	218,096	210,918	208,713	204,0

Mean discharge from 1903 to 1924 = 210,948 s-f. Mean discharge from November, 1903, to October, 1924, inclusive = 214,406 s-f.

TABLE IX.—*Showing, in s-f, the mean monthly discharge of St. Lawrence River.*

Date.	January.	February.	March.	April.	May.	June.
1860	249,965	245,806	267,019	288,910	278,101	266,012
1861	246,639	242,055	265,115	279,654	267,726	257,009
1862	253,782	245,109	267,081	281,486	265,759	259,081
1863	254,576	246,394	260,424	280,095	248,902	267,736
1864	243,945	239,213	244,577	269,674	268,425	258,181
1865	248,067	237,708	271,901	268,709	268,200	264,261
1866	252,988	240,208	268,549	267,551	262,653	249,907
1867	254,745	237,054	255,709	267,225	248,469	245,456
1868	248,267	246,545	260,911	268,209	254,659	265,478
1869	247,150	243,454	267,581	269,669	270,895	270,596
1870	249,416	251,960	272,629	268,261	267,569	259,319
1871	257,469	248,349	260,674	268,265	260,429	276,974
1872	245,962	246,987	267,668	269,086	264,776	252,277
1873	248,139	240,960	261,641	260,267	277,288	275,288
1874	244,429	244,508	260,940	272,630	261,705	264,086
1875	245,242	240,250	265,087	264,295	264,087	248,219
1876	249,297	245,288	260,980	268,728	265,150	250,615
1877	253,213	250,016	262,514	260,257	265,261	262,645
1878	246,405	251,660	267,749	264,688	276,813	270,205
1879	256,643	249,478	245,583	260,688	272,178	272,940
1880	249,520	249,580	266,771	251,606	266,563	264,706
Mean	248,284	246,906	248,044	267,271	261,290	264,894

Date.	July.	August.	September.	October.	November.	December.
1860	266,453	264,080	272,728	268,227	270,868	270,272
1861	261,260	264,262	262,786	266,196	266,456	262,042
1862	261,267	259,787	262,556	270,269	270,773	267,520
1863	267,164	265,214	275,265	270,681	265,264	264,251
1864	267,221	266,267	272,424	268,500	268,726	265,210
1865	260,467	274,726	269,696	268,271	264,661	262,849
1866	272,287	270,262	266,218	264,262	268,751	264,720
1867	265,482	266,264	276,212	260,089	261,026	261,427
1868	266,287	264,216	261,052	264,262	260,268	262,264
1869	264,720	264,245	261,726	270,260	266,068	272,464
1870	271,025	268,217	264,242	270,040	261,252	264,216
1871	274,720	262,216	264,269	261,772	261,226	262,220
1872	264,222	260,721	262,260	259,109	257,221	259,062
1873	274,722	267,024	262,264	264,612	261,269	264,160
1874	262,720	276,219	260,268	260,062	262,262	262,570
1875	262,221	262,260	260,272	268,722	257,267	262,220
1876	262,221	262,771	262,777	270,264	267,064	262,227
1877	262,672	262,720	262,642	267,262	262,247	262,264
1878	262,222	272,464	262,720	260,062	262,277	272,644
1879	262,267	260,211	262,262	267,267	267,640	262,262
1880	264,062	262,262	264,264	262,722	262,722	262,262
Mean	265,267	275,264	264,462	266,267	262,965	262,142

Date.	January.	February.	March.	April.	May.	June.
1881	262,264	260,164	262,262	262,712	264,221	262,227
1882	262,262	262,262	260,262	262,674	267,444	260,262
1883	262,262	264,262	262,264	266,112	271,212	269,274
1884	262,264	262,262	272,262	262,772	262,264	262,262
1885	262,262	262,262	262,262	262,262	262,262	262,262
1886	262,262	262,262	262,262	262,262	262,262	262,262
1887	262,262	262,262	262,262	262,262	262,262	262,262
1888	262,262	262,262	262,262	262,262	262,262	262,262
1889	262,262	262,262	262,262	262,262	262,262	262,262
1890	262,262	262,262	262,262	262,262	262,262	262,262
1891	262,262	262,262	262,262	262,262	262,262	262,262
1892	262,262	262,262	262,262	262,262	262,262	262,262
1893	262,262	262,262	262,262	262,262	262,262	262,262
1894	262,262	262,262	262,262	262,262	262,262	262,262
1895	262,262	262,262	262,262	262,262	262,262	262,262
1896	262,262	262,262	262,262	262,262	262,262	262,262
1897	262,262	262,262	262,262	262,262	262,262	262,262
1898	262,262	262,262	262,262	262,262	262,262	262,262
1899	262,262	262,262	262,262	262,262	262,262	262,262
1900	262,262	262,262	262,262	262,262	262,262	262,262
Mean	262,262	262,262	262,262	262,262	262,262	262,262

Date.	July.	August.	September.	October.	November.	December.
1881	262,262	262,262	262,262	262,262	262,262	262,262
1882	262,262	262,262	262,262	262,262	262,262	262,262
1883	262,262	262,262	262,262	262,262	262,262	262,262
1884	262,262	262,262	262,262	262,262	262,262	262,262
1885	262,262	262,262	262,262	262,262	262,262	262,262
1886	262,262	262,262	262,262	262,262	262,262	262,262
1887	262,262	262,262	262,262	262,262	262,262	262,262
1888	262,262	262,262	262,262	262,262	262,262	262,262
1889	262,262	262,262	262,262	262,262	262,262	262,262
1890	262,262	262,262	262,262	262,262	262,262	262,262
1891	262,262	262,262	262,262	262,262	262,262	262,262
1892	262,262	262,262	262,262	262,262	262,262	262,262
1893	262,262	262,262	262,262	262,262	262,262	262,262
1894	262,262	262,262	262,262	262,262	262,262	262,262
1895	262,262	262,262	262,262	262,262	262,262	262,262
1896	262,262	262,262	262,262	262,262	262,262	262,262
1897	262,262	262,262	262,262	262,262	262,262	262,262
1898	262,262	262,262	262,262	262,262	262,262	262,262
1899	262,262	262,262	262,262	262,262	262,262	262,262
1900	262,262	262,262	262,262	262,262	262,262	262,262
Mean	262,262	262,262	262,262	262,262	262,262	262,262

TABLE IX.—*Showing, in s-f, the mean monthly discharge of St. Lawrence River*—Continued.

Date.	July.	August.	September.	October.	November.	December.
1891	258,781	220,087	220,111	220,443	220,443	220,443
1892	207,724	202,238	273,434	226,268	202,470	241,[illegible]
1893	213,625	220,260	220,019	273,[illegible]	220,[illegible]	220,[illegible]
1894	220,260	224,073	222,[illegible]	272,170	220,[illegible]	220,[illegible]
1895	220,270	220,405	220,783	271,[illegible]	220,[illegible]	220,[illegible]
1896	224,120	222,726	220,511	270,049	224,[illegible]	220,[illegible]
1897	220,260	220,260	271,149	220,[illegible]	220,[illegible]	220,[illegible]
1898	220,226	227,720	247,709	220,[illegible]	220,[illegible]	220,[illegible]
1899	272,[illegible]	220,251	251,[illegible]	240,[illegible]	220,[illegible]	244,[illegible]
1900	220,[illegible]	220,272	270,[illegible]	220,[illegible]	220,[illegible]	241,[illegible]
1901	220,726	224,401	249,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]
1902	220,511	227,720	220,[illegible]	241,[illegible]	224,[illegible]	220,[illegible]
1903	220,169	220,251	220,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]
1904	227,094	220,626	220,[illegible]	220,[illegible]	224,[illegible]	224,[illegible]
1905	219,244	220,604	220,[illegible]	191,[illegible]	224,[illegible]	220,[illegible]
1906	227,[illegible]	224,[illegible]	211,[illegible]	218,[illegible]	220,[illegible]	220,[illegible]
1907	241,[illegible]	241,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]	218,[illegible]
1908	247,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]
1909	240,[illegible]	220,[illegible]	220,[illegible]	220,[illegible]	211,[illegible]	220,[illegible]
1910	220,[illegible]	220,717	220,[illegible]	220,[illegible]	214,[illegible]	220,[illegible]
1911	251,250	242,099	231,474	231,437	214,[illegible]	224,[illegible]
1912	241,[illegible]					
Mean	227,247	220,921	242,494	232,[illegible]	222,[illegible]	222,[illegible]

Mean discharge from 1860 to 1902—251,920 s-f. Mean discharge from November 1892 to October 1898 inclusive—248,513 s-f.

TABLE X.—*Showing, in inches, the mean monthly rainfall in the basin of Lake Superior.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											1.48	1.[illegible]
1893	1.49	0.59	0.68	1.95	3.49	4.38	3.86	1.77	3.33	2.73	2.97	1.[illegible]
1894	.86	1.75	1.14	2.57	3.32	1.83	2.74	4.38	3.35	4.38	1.48	2.[illegible]
1895	1.38	.61	1.38	1.48	1.98	3.68	3.04	3.16	3.04	1.80	2.65	1.[illegible]
1896	1.71	1.76	1.27	1.76	1.48	2.11	1.49	*3.08	3.68	2.84	2.04	1.[illegible]
1897	.99	1.34	.80	1.48	1.98	6.20	1.60	1.09	1.18	2.88	1.49	1.[illegible]
1898	1.96	1.13	1.68	3.01	2.67	3.70	1.83	3.74	3.61	2.79	2.68	.[illegible]
1899	1.37	1.87	1.48	3.36	3.32	3.70	4.38	3.74	3.61	1.69	1.30	2.[illegible]
1900	2.80	2.84	1.68	1.67	3.32	2.59	4.13	3.08	2.48	2.88	1.68	.[illegible]
1901	1.08	1.68	1.70	.87	1.48	3.13	3.13	2.79	2.65	2.65	1.96	2.[illegible]
1902	1.08	1.08	1.11	1.84	2.48	1.83	2.22	1.79	2.18	2.65	2.01	1.[illegible]
1903	1.68	1.08	1.11	1.84	2.48	3.68	3.13	3.74	3.68	2.68	2.03	2.[illegible]
1904	1.68	2.03	1.68	2.66	3.32	1.83	3.68	3.08	3.73	4.51	2.30	1.[illegible]
1905	1.70	.64	2.30	2.03	3.70	3.68	3.68	3.74	4.48	1.91	1.68	1.[illegible]
1906	2.27	1.03	.87	1.38	3.07	3.83	2.28	3.68	4.48	1.91	1.68	.[illegible]
1907	1.76	.96	1.83	2.38	4.69	1.76	4.69	3.68	1.69	2.68	4.38	1.[illegible]
1908	2.68	1.38	1.38	1.69	3.07	3.18	4.69	2.48	3.68	2.51	1.74	1.[illegible]
1909	1.13	1.77	1.68	.77	3.07	4.69	2.48	2.48	2.48	2.79		
Mean	1.60	1.36	1.38	1.90	2.84	2.72	3.06	2.70	2.73	2.68	1.97	1.[illegible]

TABLE XI.—*Showing, in inches, the mean monthly rainfall in the basin of Lakes Huron and Michigan.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											2.66	1.[illegible]
1893	2.31	2.69	1.19	1.66	4.29	5.86	4.11	1.94	2.68	3.19	2.69	1.[illegible]
1894	2.07	2.19	2.69	1.08	2.77	2.73	3.29	3.47	2.80	4.44	2.12	2.[illegible]
1895	2.03	1.74	1.80	2.48	2.69	2.61	2.67	4.69	3.04	2.69	2.03	2.[illegible]
1896	4.03	2.69	1.19	1.73	1.66	2.11	3.29	1.73	2.68	2.69	1.73	2.[illegible]
1897	2.03	2.69	2.84	2.48	2.69	2.97	1.66	2.94	2.11	2.69	2.44	2.[illegible]
1898	2.03	2.03	.[illegible]	1.08	2.11	1.66	1.77	2.69	2.11	2.69	2.44	2.[illegible]
1899	2.03	2.03	2.03	1.08	2.69	4.48	3.73	1.66	2.19	1.66	2.44	2.[illegible]
1900	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.77	1.97	2.69	2.03	2.[illegible]
1901	2.71	2.03	2.03	2.03	2.69	2.84	2.03	3.77	1.69	1.74	1.70	2.[illegible]
1902	2.44	2.03	2.03	2.03	.20	1.97	2.84	3.77	1.69	2.19	2.03	2.[illegible]
1903	2.71	2.03	2.03	2.03	4.17	2.84	2.03	3.18	2.81	2.19	2.03	2.[illegible]
1904	2.71	2.03	2.03	2.03	2.69	2.84	2.84	3.03	2.84	2.69	2.11	2.[illegible]
1905	2.73	2.03	2.03	2.03	2.69	2.84	2.84	3.03	2.84	2.69	2.11	2.[illegible]
1906	2.03	2.03	2.03	2.03	2.69	2.84	2.73	3.18	2.84	2.69	2.28	2.[illegible]
1907	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
1908	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
1909	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
1910	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
1911	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
1912	2.03	2.03	2.03	2.03	2.69	2.84	2.03	3.03	2.84	2.69	2.28	2.[illegible]
Mean	2.90	2.39	2.01	2.39	2.84	2.90	2.66	2.75	2.94	2.93	2.39	2.[illegible]

TABLE XII.—*Showing, in inches, the mean monthly rainfall in the basin of Lakes St. Clair and Erie.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											2.56	2.23
1893	1.66	3.94	1.45	2.03	6.66	4.96	5.13	2.02	3.87	3.21	3.01	2.31
1894	2.15	3.91	2.61	1.51	2.72	3.20	3.61	1.76	2.37	2.46	1.96	2.81
1895	2.70	1.36	.96	2.64	3.91	4.78	2.89	3.34	3.56	3.79	3.21	2.50
1896	3.39	1.99	2.52	2.61	2.64	2.47	1.91	2.97	4.45	1.49	3.77	3.19
1897	1.97	6.11	1.94	1.73	2.49	3.03	1.43	2.93	2.71	3.25	3.13	2.86
1898	2.54	1.76	2.66	2.25	2.95	2.29	2.90	2.55	3.22	2.57	3.48	1.76
1899	2.19	1.66	1.60	3.15	4.51	3.43	2.71	1.13	2.77	1.44	3.41	3.43
1900	4.11	3.10	2.89	3.31	5.30	2.88	1.98	2.44	3.49	4.20	2.96	1.43
1901	2.14	4.20	3.13	2.06	1.61	2.96	2.76	2.31	1.98	2.07	4.55	2.30
1902	2.26	2.76	2.43	2.55	7.97	5.99	3.43	2.88	3.43	1.10	3.08	1.66
1903	2.79	4.56	3.13	4.75	4.11	2.89	3.43	2.07	1.50	3.40	3.10	3.33
1904	1.92	2.75	1.61	3.05	5.53	2.02	1.03	.97	4.01	3.21	1.88	2.20
1905	3.15	.71	1.43	1.96	2.39	1.80	3.09	2.74	3.39	1.87	4.08	4.02
1906	1.79	2.60	2.60	2.98	2.57	3.79	4.52	3.54	4.50	1.79	2.51	1.95
1907	2.51	1.66	3.62	2.59	3.62	4.77	4.04	2.89	.79	1.51	5.29	2.09
1908	3.73	2.47	4.11	1.87	3.21	2.91	2.99	2.92	2.91	2.40	.....	.....
Mean	2.61	2.84	2.38	2.62	3.95	3.21	2.98	2.65	2.81	2.42	3.35	2.51

TABLE XIII.—*Showing, in inches, the mean monthly rainfall in the basin of Lake Ontario.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											1.96	2.37
1893	2.00	2.94	1.84	2.01	5.90	4.90	4.69	2.37	2.84	2.30	2.18	1.93
1894	3.67	3.08	2.11	1.13	2.64	3.46	3.46	2.89	2.22	3.43	2.28	3.05
1895	2.82	1.79	.89	2.98	2.74	4.05	3.16	3.68	3.13	4.09	2.30	2.95
1896	3.79	2.02	2.05	2.20	2.21	2.83	2.88	2.77	3.77	1.96	4.74	1.97
1897	2.75	4.30	1.82	1.89	1.94	2.77	1.73	2.77	1.74	3.30	2.03	2.73
1898	2.47	1.84	2.75	2.85	2.35	3.39	1.86	4.13	3.40	4.29	3.59	2.70
1899	3.91	2.81	1.62	3.16	3.39	6.19	5.17	2.03	3.10	3.47	5.80	3.41
1900	3.98	3.39	3.09	2.90	4.26	4.24	2.79	4.81	4.06	4.90	2.98	2.98
1901	3.06	3.66	3.25	1.96	1.19	2.73	4.39	4.24	1.62	3.96	2.86	4.08
1902	1.72	2.29	2.93	1.09	5.91	5.39	4.26	3.70	3.16	1.99	3.66	1.46
1903	2.09	3.56	2.13	3.53	5.01	3.30	3.32	4.05	3.94	3.31	2.03	3.22
1904	2.94	2.61	1.62	3.15	6.77	3.23	2.69	1.49	4.07	4.22	2.07	2.45
1905	2.64	1.77	1.67	1.99	2.65	2.57	2.60	2.69	2.29	1.41	3.64	3.94
1906	3.10	4.47	3.03	1.07	3.89	2.09	4.96	2.30	4.36	2.05	3.66	1.43
1907	2.27	1.66	3.07	2.46	3.35	3.96	3.13	2.86	3.03	.90	4.20	3.04
1908	3.71	3.09	3.19	2.51	3.58	3.00	3.30	3.37	3.30	3.08	.....	.....
Mean	2.91	2.70	2.42	2.39	3.71	3.58	3.30	3.05	3.16	2.98	3.09	2.74

TABLE XIV.—*Showing, in degrees F., the mean monthly temperature in the basin of Lake Superior.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											39.1	14
1893	0.5	7.2	32.6	44.6	42.5	66.4	69.6	66	50.7	39.1	29.9	13.3
1894	2.3	2.7	16.6	33.9	47	60.3	68.6	69.3	53.1	43.4	28.2	10.9
1895	0.0	1.2	11.9	34	45.8	55.6	66	64.5	53.4	38.9	29.1	17.1
1896	2.6	8.8	21.3	38.1	39.3	58	63.5	61.6	51.2	46.8	34.5	7.9
1897	−1.1	3.2	16.7	34.2	52	65.6	64.8	69	56	37.4	28.9	15.1
1898	−.4	6.6	10.9	31.9	40.6	55.7	60.7	57.9	50.7	37.7	27.7	19.7
1899	15.4	4.1	29.5	36.4	48.5	65.1	61.6	61.3	55	44.5	27.6	26.6
1900	9	11.6	16.7	37.4	41.3	55.1	65	57.6	51.8	46.6	32.3	16
1901	15.2	8.5	16.2	36	46.3	64.1	57.7	63.9	52.6	42.4	28.3	23.2
1902	6.6	12.9	20.9	38.9	42.6	55.9	64.9	62.9	52	44.4	28.6	11.6
1903	1.1	4	16.6	29	42	61.6	66.3	61.3	54.7	41.9	28.2	8.5
1904	5.7	10	26	37.9	46.6	61.3	64.3	63.6	56.6	44.3	33.1	21.9
1905	5.3	7.9	18	40.2	50	57	62.6	63.7	55.2	37.3	29.5	17.7
1906	10.5	12.9	18.7	37.8	48.6	60.3	66.7	61.9	53.7	39.6	32.6	17.9
1907	8.7	13.2	17.8	36.3	46.6	59.2	66.5	60.1	58.7	45.6	34.6	19.1
1908	15.3	14.6	30.7	37.3	50	55.9	63.7	60.7	54.6	40.4	.....	.....
Mean	6.2	8.2	18.4	35.7	46.3	57.2	62.2	63.1	53.9	41.1	30.6	15.7

TABLE XV.—*Showing, in degrees F., the mean monthly temperature in the basin of Lakes Huron and Michigan.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	28.8	26.6
1861	19	16.9	26.4	36.2	46.2	58.4	68.8	66.2	54.1	44.4	28.4	26.6
1862	19	18.9	26.7	36.2	45.7	59	68.5	66	61.6	45.6	30	26.6
1863	11.9	8.9	17.5	37.6	46.3	58.7	66	66.1	56.9	43.9	28.7	26.6
1864	15	13.9	27.6	40	46.1	59.2	68.2	64.8	56.9	46.4	31.6	27.9
1865	12.1	13.6	26.9	39	46.1	60.6	70.3	66.4	58	46.5	32.6	24.7
1866	19.3	16.4	29.6	38.9	46.3	61.7	68.9	66.3	58.5	47.9	34.7	28.3
1867	20.4	12.6	30.1	41.5	49.7	60.6	69	64.8	57.6	49	34.1	28.6
1868	22.6	24.4	30	41.9	48.9	61.6	68.5	64.7	54.9	45.5	40.4	32.6
1869	23.1	21.6	34.9	41.6	49.4	61.6	67.3	64.3	58.6	44.9	34	31.6
1870	18.3	20.9	29.4	39.7	48.9	60.7	68.9	65.5	58.7	47.6	33.5	29.3
1871	9.6	15.3	30	36	46.6	60.9	67.3	64.3	57.9	47.9	33.3	29.3
1872	21.9	17.5	34.7	42.5	50.1	63.3	69.3	66.1	60.6	47.5	36.9	29.3
1873	14.9	13.9	30.6	42.3	52.9	64.9	68.1	65.6	58.9	46.4	33.3	29.3
1874	22.6	20.7	33.5	42.9	51.8	63.7	68.4	65.9	58.6	46.7	37.5	29.3
1875	19.1	20.7	27.4	40.1	48.6	59.6	68.7	66.3	62.7	51.9	38.6	32.6
1876	20.4	21.6	30.6	40.4	50	61.6	67.6	65.5	61.6	48.7	.....	.....
Mean	18.9	18.1	28.6	40.9	48.4	61.4	68	65.8	58.3	45.8	33.9	28.1

TABLE XVI.—*Showing, in degrees F., the mean monthly temperature in the basin of Lakes St. Clair and Erie.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	40.4	34.6
1861	21.6	23.6	33.5	44.9	54.1	66.6	70.3	67.3	59	50.7	42.3	34.6
1862	25.3	27	33.1	43.1	53.4	66.4	68.5	66.1	67.2	44.9	39	34.6
1863	23.3	21.4	31.4	43.1	53.6	65.5	67.3	65.6	61.6	48.6	44.1	34.6
1864	23.3	24.3	34.3	47.3	54.3	66.4	68.5	65.7	60.1	49.1	37.4	34.6
1865	20.3	20.4	33.1	46.6	53.6	67.8	69.3	66.3	60.2	48.1	36.6	34.6
1866	25.6	24.3	34.3	46.6	54.3	67	68.5	66.1	60.2	48.1	40.6	34.6
1867	23.6	23.3	33.5	45.4	53.4	66.9	67.1	65.7	60.1	48.3	40.6	34.6
1868	23.6	23.3	33.5	45.4	53.4	66.9	67.1	65.7	60.1	48.3	40.6	34.6
1869	23.4	23	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1870	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1871	23.4	23	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1872	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1873	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1874	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1875	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	40.6	34.6
1876	23.4	23.3	33.6	46.4	54.3	66.9	67.1	66.1	60.2	48.1	.....	.....
Mean	24.5	23.9	33.1	45.9	53.5	67.2	71.1	66.6	60.2	50.7	40	35.6

TABLE XVII.—*Showing, in degrees F., the mean monthly temperature in the basin of Lake Ontario.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	36.7	34.6
1861	21.9	22.9	32.3	43.7	53.4	66	68.6	66.3	54.3	46	36.5	34.7
1862	24.3	25.4	32.9	42	52.3	66	68.6	66.3	62	45.5	38.2	32
1863	19.3	21.7	31.1	42.6	52.3	65.9	68.3	66.7	56.8	45.6	37.6	32
1864	23.7	23.6	33.5	44.5	53.3	67.1	69	64.8	56.5	46.2	33.1	34.7
1865	23	22.6	32.1	43.6	52.3	68.1	72.1	68	58.1	44.5	36.2	32.1
1866	24.7	23.6	32.9	43	53.3	68	68.9	66.8	58.1	45.2	37.6	32
1867	23.2	23.6	32.1	43.1	52.3	67.9	68.8	66.6	61.9	48.1	38.1	32.6
1868	23.1	21.6	34.6	41.4	49.3	67.6	67.3	65.7	57.1	46	38.9	32.6
1869	23.1	21.6	34.1	42.7	51.3	68	68.4	66.3	58.6	46.6	38.9	32.6
1870	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1871	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1872	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1873	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1874	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1875	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	34.3	32.6
1876	23.1	21.6	34.1	42.7	51.3	68	67.4	66.3	58.7	46.9	.....	.....
Mean	23.5	21.5	33.4	41.8	52.6	68.3	67.4	66.2	56.9	46.6	36.4	32.5

TABLE XVIII.—*Showing, in per cent, the mean monthly relative humidity in the basin of Lake Superior.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897											76.4	78.9
1898	79.1	78.8	70.2	66.2	66	69.5	66	70.1	71.1	74.7	73.1	76.8
1899	76.9	76.6	73.7	70.3	65.5	70.7	72.1	74.6	72.9	66.7	75.3	80.3
1900	73	73.5	75	71.3	68.3	72.7	74	74.7	69.7	73.7	66	68.7
1901	68.7	68.7	76.2	76.9	64.7	71.7	70.4	76	74	72.3	73.7	76.7
1902	78.3	77.7	75.3	73	70	76.7	77.3	77	72.3	70.7	73	81
1903	78.7	83	80.7	77.2	70.7	75.7	76.2	76.5	77.5	79.3	68.2	82.6
1904	84.2	84	76.2	74.7	70.5	73	76	75.9	77.7	77.5	80	81.7
1905	82.3	80.5	77	68.6	71	76.2	74	76	77.2	78.2	76.6	78.3
1906	82	81.6	80.5	74.5	68.5	68.6	71.5	74	75.3	72.5	82.2	84
1907	81	84	79.5	75.5	72.3	75.5	70.8	77.6	79.5	77	82.5	83.5
1908	80.2	74.6	75	79.2	68.5	71.2	74	73	76.3	69.5	81	80
1909	80	84	84.5	73.8	70.3	68.8	67.2	74	72.8	68	84.2	85
1910	85	85.8	74.5	71.5	76.2	75	74.8	73.2	74	73	82.2	82.5
1911	86	82.8	76.8	79.5	74.5	70	71.5	72.2	77.5	79.2	87.6	85
1912	85	87.2	84.2	77.2	67.2	73.8	79	77	76.6	82.5	85	86.5
1913	86.8	86.2	83.8	80	73.2	76.8	75	76.8	75.5	80	.....	.....
Mean	81.9	80.8	77.8	73.7	69.9	72.1	73.2	75	75	76.5	80	81.7

TABLE XIX.—*Showing, in per cent, the mean monthly relative humidity in the basin of Lakes Huron and Michigan.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896											78.4	80.9
1897	79.3	77.8	71.4	67.7	71.4	76.6	73.1	73.4	73.3	74.9	75.1	78.4
1898	75.2	75.8	75.3	69	68.5	73.2	72.5	73.7	74.1	73.4	70	82.4
1899	73	73.5	77	73.5	74	73.6	73.6	76.4	76	80.6	81	82.6
1900	84.2	80.6	80.6	79.4	72.8	75.3	75.2	77	76.8	75	76.8	80.5
1901	81	82.5	78.3	80.2	68.5	74.2	70.8	72.5	75	73.2	75.5	84.7
1902	82.8	82.5	79.6	71.3	74.7	71.6	72.8	75.7	77.6	79.8	80.7	80.4
1903	84.3	81.8	78.6	79	73.2	81.1	74.8	72.3	76.7	79	82.7	81.8
1904	84.1	84.1	78.3	80.2	72.4	74.4	70.7	74.6	77.1	82.1	77.1	79
1905	84.4	82.7	80.1	74.1	69.6	72.9	70.8	74.7	74.8	74.3	79.6	77.8
1906	83.6	82.8	76.8	70	72.7	69.3	72.7	76.3	76.1	75.1	80.3	82.2
1907	83.6	81	80.8	79	71	74.3	72.6	71	74.2	78.9	78.9	82.4
1908	82.6	80	76.1	78.1	78	70.3	68.3	70.4	75.6	73.7	78.6	78.7
1909	81.1	80.1	79.4	76.4	69	68.7	68.4	71.4	71.3	68	77.6	81.3
1910	82.6	79.7	84.3	76.7	70.8	69.6	73	74.7	80.6	79.4	82.4	80.1
1911	82.2	81.1	81.2	76.7	71	72.4	74.7	74.6	75.8	77.4	78.7	82.6
1912	83.1	82.7	79.7	70.7	74.1	75.7	70	79	76.9	82.6	.....	.....
Mean	81.8	81.2	77.5	73.9	71.5	74	72.1	74.3	75.8	76.5	78.8	81.2

TABLE XX.—*Showing, in per cent, the mean monthly relative humidity in the basin of Lakes St. Clair and Erie.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1896											72.4	76.5
1897	73.2	77.9	70	66.8	66	70.6	70.5	67.3	71.9	72.6	66.5	72.5
1898	77.6	80.7	73.2	66.7	67.2	70.1	68.2	66.2	71	71.9	70	76.1
1899	76.1	76.5	73.2	72.6	73.2	72.5	74.6	73.8	73.2	73.5	66	79.3
1900	81.8	77.8	76.6	74.8	72.8	72.3	69.6	72.8	70.6	72.8	74	79.6
1901	78.1	80	76.5	69.8	66	72.6	68.1	66.8	72.2	69.8	71.5	77.7
1902	81	77.6	73.1	64.7	67.6	66.8	68.6	70.6	74.6	74.5	73.2	75.6
1903	80	80.5	74.3	68.3	65.5	70	71.6	67.1	74	70.8	69.6	77.1
1904	79.6	79.5	75.6	66.1	73.3	72.6	68.8	70.6	77.5	80.6	74.3	78.7
1905	82.5	77.1	77.6	72.6	68.6	71.6	67.6	70.1	71.6	69.6	72.6	72.6
1906	79.1	82.3	77	66.5	77.6	77.7	68.8	72.3	74.8	71.7	72.6	80.3
1907	86.7	86.3	80	74.8	71.6	71.5	69	69	69.6	73.2	72.6	79.6
1908	76.8	78	69.9	79	69.1	67.8	61.2	66	72.3	74.5	74.1	77.6
1909	68	80.3	74.7	69.3	68.1	65.6	68.7	67.1	66.3	65.1	76.3	81.1
1910	82.7	81	76.1	73.1	68.5	70.6	72.5	72.8	76.6	72.1	76	80.1
1911	82.5	80.6	77.5	72.6	71.6	67.6	71.1	71.1	65.5	69.1	77.8	79.6
1912	79.6	79.8	75.6	66.8	71.9	70.5	67.8	72.8	72.3	73.8	.....	.....
Mean	80.1	79.6	75.4	70.1	70.1	71.1	69.5	70.2	72.3	72.6	73.1	77.9

TABLE XXI.—*Showing, in per cent, the mean monthly relative humidity in the basin of Lake Ontario.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											74.8	80.2
1893	78.4	76.5	74.7	76.8	73	76.6	75	71.8	74.2	72.6	69.1	77.4
1894	78.2	78.9	77	73.8	72.8	70.7	73.5	70.4	74.6	73.5	76.5	78.6
1895	80.2	80.3	80.2	74.7	76	77.6	80	81	77.7	81.3	81.3	80
1896	82.7	80.7	81	73	74.2	73.3	74	73.7	76.3	79.3	79	84
1897	84.2	80.7	78	67	67.7	73.7	73	70.3	80.7	73.7	71.3	82.7
1898	82.7	79	80.2	68.7	71	70	66.2	66.7	79	77	78.3	79
1899	80	80	78.7	66.7	72.3	73.3	72.7	72.7	78	77	80.7	79
1900	81.3	81.3	79	66.7	72.3	72.3	67.7	72.3	76.3	79	77.7	83.3
1901	80.7	79	76.3	71.3	67.3	67.3	66.3	70.3	74	66.7	70.3	79.7
1902	79.7	81.3	79	68	76.3	77	70.3	72.3	71	73.3	77.3	80.7
1903	81.7	80	76.3	72.7	73	79	70.7	73.3	76.3	73.3	72.7	82.7
1904	78.3	78.3	73.7	67.3	71.3	70	70.7	66.7	74.3	73.7	74.3	79
1905	80	78.3	77.7	68.3	68	72	72.3	67.3	67.7	73.7	68.3	83.3
1906	80.7	81.7	76.7	74.3	65.7	66.7	71	70	72.7	73.7	74.3	78
1907	79	78.7	76	67.3	69.3	67.3	74.3	71.3	67.3	69	77.3	79.3
1908	78.3	78.7	71.3	68	72.3	74	67	74.3	76	78	.....	.....
Mean	80.2	80.2	78.5	70	71.2	72.3	72	72.4	73.7	74.6	75.7	79.9

TABLE XXII.—*Showing, in miles per hour, the mean monthly velocity of wind in the basin of Lake Superior.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											9.4	9.3
1893	11.3	9.9	11.1	10.3	10.4	9	7.5	7.2	7.7	8.3	8.9	10.7
1894	8.9	8.6	7.4	8.2	8.7	8.3	7.2	8.6	8.7	11.1	10	9.1
1895	7.6	7.9	8.5	8.4	8.4	7.9	8.6	8.1	8.3	8.7	9.4	8.3
1896	10.3	11.6	9.4	9.3	8.6	7	7.2	7.4	8.9	9.5	10.6	9
1897	9.3	9.3	8.6	10.3	8.3	8.1	7.1	7.6	8.6	10	8.9	9.6
1898	8.9	8.9	8.7	8.7	8.3	8.9	8.6	8.8	8.4	7.5	7.3	9.3
1899	7.8	8.3	8.7	9	8.3	7.9	7.1	7.9	8.1	7.9	8	7.8
1900	8.6	10.6	9.4	8.9	8.3	7.5	7.9	8.3	8.9	8.3	8.9	9.7
1901	7.9	8.2	8.8	8.5	8.9	8.6	7.6	8.9	8.2	8.8	8.2	10.1
1902	9	8.7	9	11.3	8.9	7.6	7.1	7.4	8.2	8.6	10.1	7.9
1903	8.9	9.3	10.2	11.3	8.9	8.9	7.7	8.4	8.9	8.3	9.4	9.6
1904	9	8.5	10.7	9.4	10.3	8.3	7.7	7.3	8.9	10	10.3	9.7
1905	8.5	10.3	10.1	10.1	9.9	8.7	8.4	9	11.1	11	8.5	10.4
1906	9.6	10.5	11.5	11	10.7	8.8	7.8	8.6	10.4	9.7	10.3	9.3
1907	10.7	9.6	10.2	11.3	9.7	9.4	7.9	8.6	9.7	9.6	10.3	9.3
1908	9.3	10.3	11.6	10	9.6	9	8.7	7.9	9.6	10.7	.....	.....
Mean	9	9.4	9.8	10	9.3	8.2	7.5	7.9	9.2	9.5	9.5	9.4

TABLE XXIII.—*Showing, in miles per hour, the mean monthly velocity of wind in the basin of Lakes Huron and Michigan.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892											9.5	10.1
1893	11	11.5	10.6	11	11.1	8.5	8.6	8.1	8.4	10	12.5	10.6
1894	10.4	9.8	9.4	10.7	9.6	8.9	7.6	8.1	8.2	10.4	9.6	10.7
1895	8.4	8.6	9.6	10.3	8.6	8.6	7.5	7.8	8.1	8.9	10.3	11.3
1896	10.7	11.6	10.4	9.3	8.9	7.8	7.5	7.9	8.3	8.3	11.9	9.6
1897	10.4	11.1	10.3	11.1	9.2	8.9	7.8	8.2	8.3	8.3	9.6	11.4
1898	10.4	10.1	11.2	11.1	9.2	8.9	7.8	8.2	8.3	8.3	8.9	10.8
1899	10.6	10.4	9.7	10.1	10.3	7.8	7.9	7.7	8.3	8.7	8.9	10.1
1900	10.4	12.4	11.2	11	10.3	8.7	7.9	8	8.3	8.7	11.5	11.4
1901	9.6	10.6	10.6	10.6	10.3	8.9	8.3	8.8	8.4	11	11.2	10.4
1902	10	10.3	11.3	12.6	11.4	8.9	8.3	8.4	8.4	10.7	11.7	10.1
1903	10.6	10.6	10.6	12.4	11.1	9.1	8.3	8.4	11.3	11.6	11.9	10.6
1904	11.3	10.4	10.7	10.4	11.1	8.9	8.3	8.3	8.4	10.6	12.1	10.6
1905	10.7	10.6	10.7	10.6	10.7	8.6	8.7	8.3	11.6	10	11.2	11.3
1906	10.7	12.6	11.3	10.3	11.4	8.6	8.7	8.3	10.4	10.1	10.1	9.9
1907	11.3	11.1	11.7	10.3	10.4	8.9	8.3	8.3	8.4	11.3	12.6	11.3
1908	11.3	12.3	11.1	11.3	10.4	8.9	8.3	8.3	8.4	11.3	.....	.....
Mean	11.3	11.5	11.4	11.5	10.4	8.8	8.3	8.3	9.4	10.4	11.4	11.3

TABLE XXIV.—*Showing, in miles per hour, the mean monthly velocity of wind in the basin of Lakes St. Clair and Erie.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860											10	11.5
1861	11.6	11.7	11.5	10	10.3	7.6	7.5	8.1	8.7	9.7	12.2	11.8
1864	11.4	10.2	9.8	9.8	8.5	7.4	8.1	7.9	9	10.4	11.6	12.6
1865	12.2	10.2	11.2	10.9	9.1	8.9	8.3	8.5	9	9.4	11.4	12.9
1866	11.2	12.6	10.8	10.3	8.3	7.7	7	7.7	9	9.1	12.7	10.4
1867	14.2	13	10.9	11.2	7.7	7.1	8	7	8.2	10.7	12.1	10.6
1868	10.7	10.4	12	9.6	9.2	8.6	7.5	8.5	8.6	10.7	11	12.3
1869	12	12.1	9.6	9.6	9.7	8.4	7.3	7.7	8.3	9.8	10.2	12
1870	12.6	11.6	11.7	10.3	8.6	8.3	8.2	7.3	8	8.8	10.8	11.8
1871	9.1	12.4	11.6	9.9	8.5	7.5	8.7	7.7	7.9	10.4	12.6	10.1
1872	11.8	10.3	10.4	12.2	10.7	8.2	7.9	8.7	10	11	12.2	11.1
1873	11.7	12.4	12.7	14.2	10.6	8.3	8.2	8.4	11	11.2	12.1	14.1
1874	12.1	13.2	12.9	9.6	10.2	8.5	9	7.8	9.6	10.3	14.1	13.2
1875	13.2	13.1	12.5	10.3	9.7	8.1	8.5	8.1	10	12.6	11	12.4
1876	10.3	13.8	12.4	11.9	11.3	8.7	9.6	9.3	10.3	10.5	14.5	11.9
1877	12.9	12.1	12.9	12.6	10.2	8.1	8.9	8.3	8.5	10.5	14	12.7
1880	13.4	13.5	11.5	11.5	9.4	8.3	8.7	8.7	10.4	13	.....	.....
Mean	12	12	11.6	10.9	9.5	8.3	8.3	8.2	9.2	10.5	12.1	12.1

TABLE XXV.—*Showing, in miles per hour, the mean monthly velocity of wind in the basin of Lake Ontario.*

Date.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1860	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.5	12.6
1861	12.1	15	12.4	9.1	11	7.5	8.1	8	7.7	12.4	13.4	12.2
1864	14.6	12.5	11.1	9.3	10.1	7.2	8.7	8.2	9.7	11.7	12.2	14.2
1865	16.2	12.7	13	11.1	8.9	9.3	8	8.2	8.5	9.1	11.2	14
1866	12.8	15..	12'	9.9	9.3	8.9	7.8	8.3	9.6	10.6	15.2	12.5
1867	16.5	15.2	12.8	11.9	7.5	7	8.2	7.8	9.1	11.3	12.6	11.9
1868	13.6	12.1	12.5	11	9.4	8.7	7.3	8.1	8.4	11.5	11.8	12.5
1869	12.9	12.9	9.2	8.9	8.5	8.1	8.1	8.3	9.1	9.7	10.9	14.1
1870	12.8	13.2	12	10.7	8.9	7.9	9.1	8.9	7.8	9.6	12.1	12
1871	10.8	12.7	12	10.6	9.2	7.2	8.1	7.4	7.9	9.7	13	13.2
1872	11.6	10.8	12.1	11.5	9.7	8.1	7.8	7.6	8.7	10.1	11.4	11.9
1873	12.1	13.2	12.4	11.9	9.3	7.6	8.7	7.4	9.4	10.5	12.7	12.7
1874	12.6	12.9	11.9	9.7	8.8	8.3	8.2	7.8	8.4	10	13.1	12.9
1875	13.7	14.5	11.6	8.8	8.7	6.5	7.9	7.5	8.6	12.2	10.9	11.6
1876	9.9	14.2	14.9	10.9	11.2	8.8	9	9	9.5	9.9	13.6	12.6
1877	14.7	13.5	14.1	13	10.8	9	8.5	8.7	8.9	10.2	14.4	13.1
1880	12.9	11.9	11.8	11.2	9.1	8.6	8.4	9.3	10.1	11.3	.....	.....
Mean	13.2	13.2	12.3	10.5	9.4	8.2	8.3	8.1	9	10.6	12.5	12.9

REPORT

ON

REGULATION OF LAKE ERIE.

INTERNATIONAL WATERWAYS COMMISSION.

OFFICE OF THE AMERICAN SECTION,

BUFFALO, N. Y., January 8, 1910.

1. The act of the Congress of the United States, approved June 13, 1902, which requested that the Government of Great Britain be invited to join in the formation of this Commission, defined one of the duties of the Commission as follows, viz.:

"The said Commissioners shall report upon the advisability of locating a dam at the outlet of Lake Erie, with a view to determining whether such dam will benefit navigation, and if such structure is deemed advisable, shall make recommendations to their respective Governments looking to an agreement or treaty which shall provide for the construction of the same, and they shall make an estimate of the probable cost thereof."

2. The Great Lakes, lying between the United States and Canada, with their connecting channels and their natural outlet to the sea, the St. Lawrence River, of which a description will be found in the appendix to this report, constitute the most important system of inland navigation in the world. The traffic which passed through the Detroit River, its busiest link, in 1907, amounted to 71,226,895 tons, valued at about $700,000,000. About 70 per cent. of this traffic is carried in large freight carriers which are loaded down to the greatest draft that can be carried into the harbors or through the channels between the lakes. With the depth now available they are usually loaded to a draft of about 19 feet, but careful watch is kept upon the stage of the waterways and advantage is taken of any temporary increase of stage to load the vessels deeper. The number of deep-draft vessels, as well as their size, and the share of lake traffic which they carry is increasing each year, while the lake traffic itself is increasing with great rapidity. Vessels which would carry an additional load of 85 tons for each inch of additional draft have recently been

added to the fleet. Every inch added to the available depth of water would, therefore, be of material benefit to commerce.

3. The method heretofore employed for deepening the natural channels is that of excavation, but it has been suggested that a more economical and otherwise better method would be to raise the surface of the water by obstructing the flow of the outlets. For Lake Erie in particular a definite plan, with estimates of cost, was proposed by the Board of Engineers on Deep Waterways in their report dated June 30, 1900, published as House Document No. 149, Fifty-sixth Congress, first session. The official character of this report and the ability displayed in its preparation seems to have led to the provisions of law under which this Commision is now acting, and to make of it a proper starting point for this discussion. It was proposed by the Board to "regulate" the level of Lake Erie.

4. By the term "regulation of a lake's level" is meant the maintenance of its level at or near some fixed stage, which implies such control of the discharge as will make the latter nearly equal to the total supply—rainfall and inflow less evaporation—at all times. In some cases, this may be accomplished by a submerged weir in the outlet, of such length that a small increase or decrease of stage will increase or decrease the discharge over the weir by an amount equal to the change in the total supply. A work of this kind operates automatically, but manifestly it requires more or less range of stage and the topography must be such that a great length of weir can be found; it does not lend itself to the most complete regulation.

5. The works proposed by the Board were for the regulation of Lake Erie within a range so small that it might be considered almost complete regulation. They consisted of a submerged weir in connection with a set of sluice gates "so designed that with the sluice gates all closed the low-water flow of the regulated stage of the lake will be discharged over the fixed submerged weir, and with the sluice gates all open the additional volume of overflow necessary to maintain the lake at nearly the same level will pass through the sluices at times when the lake is receiving its maximum supply." They were to be placed near the angle in the Bird Island Pier, at the head of Niagara River, and were designed to hold the level of the lake at or near 574.5, old levels, or 574.7, 1903 levels, above mean tide at New York. This is higher than any monthly mean stage reached since authentic records have been kept, that is, since 1860. It was a maximum

not to be exceeded. It is not definitely stated what the minimum monthly stage would be under regulation, but it may be inferred from certain paragraphs in the Board's report that it was to be about 573.7, 1903 levels. (See paragraph 104 of the appendix.)

6. The Great Lakes constitute a series of enormous natural reservoirs, each of which serves to regulate the flow in the river constituting its outlet, and to maintain the lake below. They are inter-dependent. The study of one, to be complete, must include the study of all. The total area drained by them is about 287,688 square miles, an area considerably larger than the German Empire. Of this total, about one-third is occupied by the lakes themselves, that is, is devoted to reservoir purposes. The result is a uniformity of level and a uniformity of flow which is truly wonderful. In Table A are given the areas of the lake surfaces and of the drainage basins.

TABLE A.

LAKE	Area of Lake Surface in Square Miles	Drainage Area Including Lake Surface, in Square Miles	Ratio of Lake to Drainage Area
Superior	32,000	76,134	1: 2.37
Michigan	22,336	65,799	1: 2.95
Huron	22,978	72,008	1: 3.13
St. Clair	503	6,194	1: 12.31
Erie	9,968	34,573	1: 3.47
Ontario	7,243	32,980	1: 4.55
Total	95,068	287,688	1: 3.02

Authority: 1906 U. S. Lake Survey report.

The areas of the small lakes and streams are taken as a part of the land area.

In Table B are given the average and the extreme variations in the levels during the period from 1860 to 1907.

TABLE B.

	Superior	Huron	Erie	Ontario
	Feet	Feet	Feet	Feet
Extreme range, 1860-1907	3.52	4.64	3.89	5.34
Maximum range in 1 year	(1860) 2.67	(1876) 1.94	(1892) 2.28	(1867) 3.65
Minimum range in 1 year	(1891) 0.49	(1879) 0.59	(1895) 0.87	(1907) 0.70
Average annual range	1.18	1.21	1.56	1.60

In Table C are given the average and the extreme variations in the discharge of the outlets for the period 1860 to 1907:

TABLE C.

	St. Marys River	Detroit River	Niagara River	St. Lawrence River at its Head
	c. f. s.	c. f. s.	c. f. s.	c. f. s.
Average discharge for entire period	82,000	204,200	212,200	254,400
Greatest excess average for any one month	46,700 Sept., 1869. 57%	71,200 July, 1865. 35%	45,600 June, 1876. 21%	96,800 May, 1902. 38%
Greatest excess average for any one year	19,100 1874. 23%	30,200 1886. 15%	26,500 1876. 13%	49,000 1902. 19%
Greatest deficiency average for any one month	33,800 Feb., 1862. 41%	98,900 Feb., 1874. 48%	43,500 Mar., 1900. 20%	102,200 Feb., 1903. 40%
Greatest deficiency average for any one year	16,900 1879. 21%	30,600 1886. 15%	31,800 1895. 15%	62,800 1895. 25%

No work of man ever has approached or ever will approach this perfection of regulation. The question now is, can he add to that which exists in any important degree.

7. Evidently the answer to this question must be based upon careful analysis and close computation. The data for its solution are found in the records of the water levels, and in the measurements of discharge taken during the last 48 years, principally under the direction of the Chief of Engineers, U. S. Army. Actual values assigned to rainfall and evaporation are not well determined and cannot be used. It is the relative value of these elements which it is necessary to know, and that value is found in the discharge measurements.

8. Soon after the organization of the Commission, a committee of two of its engineer members was appointed to collect all of the available data, and to make an hydraulic analysis of the general regulation of all the lakes. It was well known at the outset that this would be a long and laborious task, but it proved to be more so than was expected, and it was only recently completed. The full report of the committee is hereto attached as an appendix. A brief synopsis of it is here given.

9. Beginning about 1860, and continuing to date, daily or tri-daily water-level observations have been taken at Mar-

quette on Lake Superior, Milwaukee on Lake Michigan, Cleveland on Lake Erie, and Oswego and Charlotte on Lake Ontario. Beginning at later dates, observations have been taken at Sault Ste. Marie, Harbor Beach on Lake Huron, St. Clair River, St. Clair Flats Canal, Windmill Point on Lake St. Clair, Amherstburg on Detroit River, Buffalo on Lake Erie, Ogdensburg on St. Lawrence River, and Lock 27 at the head of Galop Rapids, Lock 24 at the head of Rapide Plat and Lock 21 at the head of Long Sault Rapids, on St. Lawrence River. Self-registering automatic gages giving a continuous graphical record of the rise and fall of the water were not installed until 1899. The record for each of the above-mentioned gages, except the last two, from 1860 to 1907, inclusive, has been completed by interpolation. For Lock 24, on the St. Lawrence, the record has been completed from 1880, and for Lock 21, from 1870. There are a few isolated records of dates earlier than 1860, but they are not well authenticated and cannot be used here.

10. As was stated in our report of January 4, 1907, upon the Chicago Drainage Canal, "Variations in the level of the lake's surface, due to winds and to change of barometric pressure, are frequent and irregular and at times violent. Variations of more than 6 inches are very common, often occurring hourly for many hours in succession, while variations of 2 or 3 feet within an hour are not uncommon. Besides these irregular variations there is a regular annual variation due to difference in rainfall, evaporation, and run-off, the water level being highest in midsummer and lowest in midwinter. The levels are affected also by the greater or less severity of the winter and by the consequent greater or less decrease in the discharging capacity of the outlets by ice. In order to study the annual oscillations it is necessary to eliminate the irregular oscillations, and that is accomplished by using the average levels for a month." The monthly mean stage has been obtained by taking the average of the gage readings for a month, and is given for each of the above-mentioned gages in Tables 2-17. The monthly mean stages of Lakes Superior, Michigan-Huron, St. Clair, Erie, and Ontario, from 1860 to 1907, inclusive, are shown on Plate 1.

11. The volume of discharge of the outlet at any given stage is obtained from a formula deduced from actual measurements of discharge at such stages as happened to exist at the time of observation. Formulae of this kind were deduced for each of the outlets of the Great Lakes. During the winter of 1896 discharge measurements of the St. Marys River,

the outlet of Lake Superior, were made at Spry's Dock Section, located about a mile below the St. Marys Rapids. In 1902 discharge measurements of the same stream were made at the International Bridge which connect Sault Ste. Marie, Mich., with Sault Ste. Marie, Ontario. In 1905 similar measurements were made at "Section Brewery," located about 2,000 feet below Spry's Dock Section. All of these observation were made by the U. S. Lake Survey. Up to the year 1887, the discharging capacity of the St. Marys River remained nearly uniform. Since that date, numerous artificial works have been constructed at the Sault, which have modified its discharging capacity to an important degree. During the years 1887 and 1888, the International Bridge was built, which with its piers and approaches materially reduced the cross section. In 1892, the Edison Sault Electric Company placed power works in the bed of the stream. In 1895, a power canal on the Canadian side was opened to use. In 1905, a power canal on the Michigan side was opened to use, compensating works in connection therewith having been placed in the river in 1901 and 1902. The amount of water diverted by the power canals has increased from time to time since they were opened, and so has the quantity used by the American and Canadian locks. To conform to these changes it was necessary to deduce eleven different discharge formulae for the St. Marys River alone.

12. The discharge formula for St. Clair River, the outlet of Lake Michigan-Huron, was deduced from observations made by the U. S. Lake Survey in 1899, 1900, 1901, and 1902.

In 1900, the Chicago Drainage Canal began diverting water from Lake Michigan. The amount diverted between January, 1900, and June, 1904, inclusive, was computed from data furnished by the U. S. Engineer Office at Chicago. The flow through the canal since June, 1904, has been assumed to be 4,167 cubic feet per second, the quantity authorized in the permit of the Secretary of War. It is believed to have been greater, but the difference is not sufficient to vitiate the results sought for here. An application by the Commission to the Sanitary District of Chicago for a copy of their record met with a refusal to furnish it.

13. The discharge formula for the Detroit River was derived from measurements taken at Fort Wayne, Michigan, by the U. S. Lake Survey in 1901 and 1902.

14. For the Niagara River, the outlet of Lake Erie, discharge measurements were made at the International Bridge at Buffalo, and at a point about 1,800 feet down stream, called

the "Open Section." These observations were begun in 1897 for the Board of Engineers on Deep Waterways, and were continued in 1898, 1899, and 1900, by the U. S. Lake Survey.

15. The discharge formula for the St. Lawrence River, the outlet of Lake Ontario, was deduced from measurements made by the U. S. Lake Survey in 1901 and 1902 at "Three Points Section," situated about 15 miles below Ogdensburg, N. Y., and 9 miles below the head of the Galop Rapids.

16. With the discharge formulae and the gage records, the average discharge, in cubic feet per second, has been computed for each month from 1860 to 1907, inclusive, for each outlet. The results for St. Marys River are given in Table 19; those for Detroit River in Table 20; those for Niagara River in Table 21; and those for St. Lawrence River at its head in Table 22.

17. The total supply of water to a reservoir or lake depends upon the inflow or transmitted supply from another watershed, the precipation on the surface of the lake, the run-off from the lake's watershed, and evaporation from the lake's surface, or the outflow from and storage in the lake. Of these factors, for the Great Lakes, the transmitted supply, the discharge, and the storage are known separately, while the value of precipitation, run-off, and evaporation is known collectively. The local supply for any lake is the water-yield from its own watershed, and is equal to the total supply minus the transmitted supply or inflow from the watersheds situated above. The supply factors have been deduced for Lakes Superior, Michigan-Huron, Erie, and Ontario, for each month from 1860 to 1907, inclusive, and the results are given in Tables 24, 25, 26, and 27. They are shown graphically upon Plates 2 to 17 inclusive.

18. It is to be noted that minus values for the monthly mean local supply have frequently occurred, that is to say, the evaporation has frequently exceeded the precipation and run-off. For Lake Superior, minus values occurred at some time during 41 of the 48 years considered; this usually happened in December, but it sometimes occurred in each of the months from October to April inclusive. The greatest minus value occurred in December, 1870, when the evaporation exceeded the precipation and run-off by 106,600 cubic feet per second.

19. For Lake Michigan-Huron, minus values occurred in 33 out of the 48 years considered. This usually happened in September, October, or November, but it sometimes happened also in August and December. The greatest minus value oc-

curred in September, 1871, when the evaporation exceeded the precipitation and run-off by 125,700 cubic feet per second. In that year minus values occurred in each of the four months from August to November. In 1894, minus values occurred from August to December, inclusive.

20. For Lake Erie, minus values occurred with extraordinary frequency. They are found in every year, and in many years in all of the last six months. From June, 1884, to March, 1885, inclusive, that is, for 10 consecutive months, evaporation exceeded precipation and run-off continuously, the average excess for the entire period being 40,400 cubic feet per second. There is no month, except the month of May, in which a minus value has not been found in some year between 1860 and 1907. The excessive evaporation in Lake Erie may be attributed to the facts that the lake is shallow and its longer axis lies in the direction of the prevalent winds.

21. For Lake Ontario, minus values occurred less frequently than with the other lakes, but were found in 27 out of the 48 years. The greatest minus value occurred in January, 1877, when the evaporation exceeded the precipitation and run-off by 40,300 cubic feet per second.

22. To obtain the general law which governs these supply factors, Table 28 was prepared, which gives their average for the entire period from 1860 to 1907. The averages for Lakes Superior, Michigan-Huron, Erie, and Ontario, are shown graphically on Plate 18. From these, it appears that evaporation exceeds the local supply in Lake Superior during December and is nearly equal to it during January; that evaporation is nearly equal to the local supply in Lake Michigan-Huron during October and November; that it exceeds the local supply in Lake Erie during the last half of the year, July to December; and, as a general rule, does not exceed the local supply in Lake Ontario.

23. The maximum stage of one lake does not occur at the same time as that of another lake, and this is true also of the minimum stage. Nor does the maximum outflow occur at the time of the maximum total supply, nor the minimum outflow at the time of the minimum total supply. The lake may continue to fall while the supply of water is increasing and *vice versa*. These great forces require time to act. The following table shows the ratio, R, between the maximum discharge and the maximum total supply for each lake, the time interval, $T_{MAX.}$, which elapses between the maximum total supply to any lake and the maximum discharge from that

lake, and the time interval, $T_{MIN.}$, which elapses between the minimum total supply and the minimum discharge.

LAKE	R	$T_{MAX.}$	$T_{MIN.}$
Superior	0.524	98 days	91 days
Michigan-Huron	0.647	82 "	101 "
Erie	0.884	76 "	132 "
Ontario	0.955	56 "	20 "

From which it is to be inferred that the interval of time required for an increasing supply to show its effect upon the level of Lake Superior is about 98 days, and for a decreasing supply it is about 91 days; in Lake Erie, the corresponding intervals are 76 days and 132 days respectively; for the other lakes, the intervals are somewhat less.

24. With the data which have been given, it is now possible to show what the practical result will be of an attempt to regulate the level of any lake within any given limits. For illustration, the Commission has selected the regulation of Lake Erie, between the limits 573.7 and 574.7, 1903 levels, by means of a submerged weir and sluice gates, as proposed by the Board of Engineers on Deep Waterways. In this case, the sluice gates cannot be set daily or at frequent intervals, to meet conditions as they arise, because of the difficulty of ascertaining what the true level of the lake is and what its consequent discharge is at any particular time. The irregularity and occasional violence of its oscillations make it necessary to take the average of a considerable number of observations—usually those of a month—to find the true level. The gates can, therefore, be set not oftener than once a month, and then only approximately. It is necessary to fix upon some definite elevation for the stage of the lake at the beginning of each month and then to set the sluice gates to give a discharge which will bring the lake to the level desired at the end of the month. That is to say, it is necessary to estimate the total supply which the lake will receive during the month to come. For regulation between the levels 573.7 and 574.7, the stage values at the beginning of each month should be approximately as follows:

January 1	573.8	May 1	573.9
February 1	573.7	June 1	574.0
March 1	573.7	July 1 to November 1	574.0
April 1	573.8	December 1	573.9

In Table 33 are given the actual supply to Lake Erie, and the supply which would have been estimated if regulating works had been in operation for each month from January, 1890, to December, 1906, inclusive, and their difference. The table gives also the level which the lake would have reached with regulating works, and the difference between the stage reached and the stage desired. The actual supply and the stage are rarely identical with those expected, and in some cases the differences are important. For example, the actual supply in March, 1891, was 37,100 cubic feet per second less than would have been estimated, and in the following month, April, 1891, it was 47,800 cubic feet less than would have been estimated; the stage reached at the end of April, 1891, would have been 573.48, or 5 inches lower than the stage desired. In April, 1892, the supply was 40,200 cubic feet per second, and in the following month it was 29,400 cubic feet per second, more than would have been estimated, and the stage reached at the end of May would have been 574.54, or about 6½ inches higher than the stage desired. In July, 1892, the actual supply was 35,300 cubic feet per second less than would have been estimated. In June, 1893, the actual supply was 39,000 cubic feet per second less than would have been estimated, and in June, 1901, it was 32,300 more. Numerous other instances of important differences will be found in the table. They may occur in any part of the year. They show that it is not possible to foretell the stage under regulation, a month in advance, within 5 or 6 inches; that is to say, that a margin of about 6 inches must be allowed at the upper and lower limits proposed for regulation. If the attempt be made to regulate within a range of one foot, with this margin, there will be no range left for setting the sluice gates, which is absurd. In other words, the regulation of Lake Erie within a range of 1 foot, or between the limits 573.7 and 574.7, is impracticable.

25. It appears, however, from a study of Table 33, that it would have been possible during the period covered by the table, 1890 to 1906, to regulate the level of the lake between the limits 573.31 and 574.74, or within a range of about 18 inches. This period covers the extreme low-water year, 1895, but not an extreme high-water year, like that of 1876. Computations were made to ascertain the effect of regulation between the limits 572.0 and 574.5 in the two extreme years. The results are given in Table 35, and are shown graphically on Plate 21. It is found that the extreme range from high water of 1876 to low water of 1895, which was 3.78 feet, would

under regulation have been reduced to about 2.5 feet. The high levels of 1876 would not have been raised, but the low levels of November and December, 1895, would have been raised 1.38 and 1.37 feet, respectively, and the annual mean level of 1895 would have been raised about 1.07 feet. This would benefit Lake Erie, and is, therefore, worthy of examination.

26. It must not be forgotten that these numbers refer to monthly mean or annual mean stages. It sometimes happens that the stage varies as much as 7 or 8 feet in one day, and more than 2 feet in one hour. Storms raise the water level at Buffalo, several feet higher than normal, and lower it, at Amherstburg, by a like amount; the difference of level between the two ends of the lake in extreme cases having been as great as 15 feet. To control these irregular variations is impossible. It is possible only to regulate the monthly mean stage within the limits of about 2.5 feet. Whether or not it will be expedient to undertake the regulation of Lake Erie between these limits must depend upon the following considerations.

27. Effect Upon Lake Erie. An examination of Plate 21 shows that for a year of excessive supply, such as 1876, the regulation of Lake Erie would not improve navigation. In 1895, a year of deficient supply, the mean level during the eight-month season of navigation would have been raised from 571.31 under natural conditions, to 572.41 under regulated conditions, and navigation would have been improved by an increase of 1.1 feet in the stage. The extreme low stages for the navigation season would have been raised at least 1 foot without appreciable increase in the extreme high stage. This is equivalent to deepening every harbor and channel in Lake Erie by that amount.

28. Effect Upon Lake St. Clair. The increase in the stage of Lake Erie will decrease the mean slope in the Detroit River, and will cause Lake St. Clair to rise, until the slope be so far restored as to give to the discharge through the Detroit River a value equal to the natural discharge. The amount which Lake St. Clair will rise on account of an increase of 1 foot in the stage of Lake Erie, is computed to be 0.61 foot. (See paragraph 121 of the Appendix.)

29. Effect Upon Lake Michigan-Huron. As backwater from Lake Erie raises the level of Lake St. Clair, so backwater from Lake St. Clair raises the level of Lake Michigan-Huron. The effect of an increase of 0.61 foot in the stage

of Lake St. Clair is to raise the level of Lake Michigan-Huron 0.27 foot. (See paragraph 123 of the Appendix.)

30. Effect Upon Lake Ontario, and the St. Lawrence Canals. Any change in the outflow of Lake Erie will change the water levels of Lake Ontario. If the inflow to Ontario is increased the lake level will rise, and with decreased inflow the level will fall. For the extreme years, 1876 and 1895, the effect upon Lake Ontario of the regulation of Lake Erie is shown in Table 36, and on Plate 21. For the high water year, 1876, there would have been but little change; at no time during the year would the regulated stage of Lake Ontario differ from the actual stage more than 1½ inches. In 1895, the low water year, the oscillation would have been increased. The high water of May would have been about 1 inch higher, while the low water of September, October, and November would have been 4.08, 4.46, and 4.00 inches, respectively, lower under regulation than under the natural conditions. To lower the level of Lake Ontario is to lower the St. Lawrence River and to injuriously affect navigation in the St. Lawrence canals. A comparison of the gage records upon Lake Ontario and at these canals shows that a fall of 4.56 inches in the level of Lake Ontario will lower the level in the Galop canals about 4.56 inches, in the Morrisburg canals by about 6.65 inches, and in the Iroquois Canal, Lock 25, by about 7.66 inches. During periods of low-water it would be necessary to diminish the draft of vessels navigating the canals about 7.66 inches, by decreasing their loads.

31. Effect Upon Niagara River. The effect upon Niagara River would not be important. The stage would not fluctuate through any greater range than under natural conditions. During the winter months, more frequent low water would probably occur, in which case the power companies at Niagara Falls would probably have more difficulty in keeping the channels to their intakes free from ice. During the autumn months navigation might be slightly injured by the prolongation of the low-water season, due to the storage in Lake Erie of a part of the natural discharge.

32. Effect Upon the City and Harbor of Buffalo. Low-lying portions of the city of Buffalo and the adjacent territory are subject to overflow both from the lake and from tributary streams, especially Buffalo Creek. Floods from the lake are due to storms blowing from the southwest. During the severe storm of January 20, 1907, Lake Erie rose to 579.45, or 6.49 feet above the mean for that month, or 7.0 feet above the mean of the preceding and following months. Iron fur-

naces were extinguished, a pumping plant was seriously crippled, and much damage was inflicted upon the lands and property in Buffalo adjacent to the lake and to Buffalo Creek. Under regulation, the monthly mean level of the lake upon that occasion would have been about 2½ inches higher than it was and the height of the flood would have been increased by that amount. Floods from Buffalo Creek are now of common occurrence. With a few days of warm weather in the winter, the discharge of the creek becomes so great as to overflow its banks, and the water sometimes floods an area of 1,600 acres, having a population of 10,000. It is stated by the Department of Public Works of Buffalo that a rise of 2 feet in the stages of the lake causes a rise of about 1 foot in Buffalo Creek in the center of the flood district. Most of the floods in Buffalo Creek occur during January, February, and March, when Lake Erie is at its lowest stage. Some of the greatest floods have occurred during the extreme low-water periods, such as those in the winters of 1896, 1898, 1900, and 1902. With the winter level regulated at a height greater than it actually was upon those occasions, the flood height would have been increased, and greater damage would have occurred.

33. Ice Jams. During every winter ice jams form on Horseshoe Reef at the head of Niagara River. The ice in the lake is blown toward the outlet by a southwest wind, and is piled upon the shallow reef, where it forms an ice jam extending from near the bottom to several feet above the surface of the water. In some instances, the bergs have been 20 to 30 feet high. The proposed regulating works, being placed about a mile below Horseshoe Reef, would aggravate this difficulty. The neck of the outlet might become so effectively blocked with ice that the flow of the river would be materially decreased as was the flow of the St. Clair River in the winters of 1901 and 1902. If those conditions should exist, a severe southwesterly storm, such as has occurred on numerous occasions, would inundate the lower part of Buffalo. These ice jams seriously interfere with navigation. The average date of opening navigation in the spring, at Buffalo, is April 9, while at Cleveland, the average date is March 23. The difference of 17 days in the dates of opening the two Lake Erie ports is due to ice jams. It is probable that it would be materially increased by the construction of the regulating works. It is to be observed that the ice jams would make it difficult to maintain the works.

34. Effect Upon the Low-lying Shores of Lake Erie. There are low-lying portions of the shores of Lake Erie where the water is shut out by dykes and where pumping is now required. To raise the level of the lake would increase the amount of such pumping. It is possible, also, that there are points other than Buffalo, where great commercial interests are concentrated, and where local drainage is deficient, but for reasons which will appear presently it has not been considered necessary to make a detailed investigation of every locality.

35. The advantages then of regulating Lake Erie, between the limits 572.0 and 574.5, are that the low-water stages of Lake Erie will be raised about 1 foot; those of Lake St. Clair will be raised about 0.61 foot; and those of Lake Michigan-Huron, about 0.27 foot; without in any case increasing the high water stage.

36. The disadvantages are that the oscillations in Lake Ontario are increased about 5½ inches, and low water is made lower by about 4½ inches; that the depth in the St. Lawrence canals will be diminished by about 7.66 inches; that the city of Buffalo and its southerly suburbs will suffer by increased damage from floods, and from a postponement of the date of opening navigation in the spring.

37. In weighing these advantages and disadvantages, it is to be remembered that the persons who are to benefit by the former are not identical with those who are to suffer from the latter. Those navigating the St. Lawrence canals are not specially concerned with deepening the harbors of Lake Erie; nor are those occupying the low-lying portions of Buffalo sufficiently compensated for the injury to their property by the beneficial effects upon navigation. If the advantages and disadvantages could be equally distributed, we are inclined to think that the former would outweigh the latter, and that the expediency of the undertaking would be a question of cost. As the matter stands, it involves the question of damages to vested rights, which in this case is peculiarly intricate. It is our opinion that the advantages are not of such overwhelming character as to justify the two governments in entering upon that vexatious question, and we therefore recommend that the "regulation" of Lake Erie be not undertaken, meaning thereby the most complete practicable regulation such as can be secured by a dam and sluice gates located at or near Buffalo.

38. It does not follow that nothing can advantageously be done to improve or maintain the level of the lake. It is

possible to raise the level of any lake by simply reducing the size of the outlet. With a reduced cross section, the outlet requires a steeper slope, and the average level of the lake is raised, but the oscillations will go on as before, and the discharge will remain the same. To raise the level of Lake Erie will raise also, but to a less degree, the levels of Lake St. Clair and of Michigan-Huron, and will thus benefit those waters, while it will have no effect upon Lake Ontario or the St. Lawrence River. It would be physically practicable to raise the level many feet, but here again vested rights must be considered, and the amount which the level should be raised is in our judgment limited to that which will not interfere with those rights.

39. It is believed that somewhere in the Niagara River, between Lake Erie and the Falls, a submerged dam may be placed which will greatly benefit the navigation of the waters above without injury to those below and with only minor damages, if any, to the adjoining lands. Without any attempt to "regulate" Lake Erie, the level of the lake may be raised sufficiently to compensate for the damages heretofore inflicted by the Chicago Drainage Canal and other deteriorating influences. To distinguish works of this kind from those designed to "regulate" the lake, they may be called "compensating" works.

40. The upper Niagara River is a valuable safety-valve for the protection of Buffalo from the effects of storms upon Lake Erie, and should not be obstructed by a dam. It is possible that the extreme lower end of the reach, that is, the section just above the Falls, may not be available because of excessive overflow to be caused in the valley of the Welland River. To determine the best site it has been necessary to make additional surveys. These were begun in July, 1909, and are still in progress. After their completion it is our intention to submit a supplementary report upon the subject.

41. In connection with the hydraulic analysis of the general regulation of all the lakes, attention is invited to a discussion of the regulation of Lake Superior, of Lake Michigan-Huron, and of Lake Ontario, which will be found in the Appendix, paragraphs 125-132, 148-155. Without going into details it may be stated in general terms, that, as in the case of Lake Erie, only a very moderate degree of improvement in regulation over what nature provides is practicable in any of the lakes, and that, such as it is, this improvement is obtained at the expense and to the injury of the navigable chan-

nels below. If the level of any lake has been lowered, whether by diversion through the Chicago Drainage Canal or by enlargement of the outlet, the remedy seems to lie in "compensating" rather than in "regulating" works.

42. Attention is invited also to a discussion of the use of Lake Superior as a reservoir, which has been proposed by persons not familiar with the Great Lakes, to compensate for the diversion of water through the Chicago Drainage Canal (see Appendix, paragraphs 133-147). The result of the discussion is to show: 1, that Lake Superior, being naturally one of the greatest and best regulators of flow to be found in the world, maintains a flow in the St. Marys River, its outlet, which is remarkably uniform; 2, that uniformity of flow in that river is essential to the best interests of navigation of the river itself; 3, that during the winter months when navigation is suspended this uniformity of flow is still necessary to maintain the level of Lake Huron, and keep it in condition to maintain in its turn the St. Clair and Detroit Rivers in the spring when navigation opens. It is not in the power of man to improve this uniformity of flow to any important degree. He may disturb it, making it less uniform, by storing water in Lake Superior, but any water withheld at one season would create a deficiency in the lake below, which must be replaced by a equivalent increase of discharge from Lake Superior at another season. This would simply increase the oscillations in the level of the lakes below, that is, would injure them, without compensating in any degree for the diversion of water through the Chicago Drainage Canal.

O. H. ERNST,
Brig. Gen'l., U. S. Army, Retired,
Chairman, American Section.

GEORGE CLINTON,
Member, American Section.

E. E. HASKELL,
Member, American Section.

GEO. C. GIBBONS,
Chairman, Canadian Section.

W. J. STEWART,
Member, Canadian Section.

Attest:
W. EDWARD WILSON,
Secretary, American Section.

The SECRETARY OF WAR OF THE UNITED STATES.
The MINISTER OF PUBLIC WORKS OF CANADA.

APPENDIX.

INTERNATIONAL WATERWAYS COMMISSION.
OFFICE OF AMERICAN SECTION,
BUFFALO, N. Y., December 4, 1900.

THE INTERNATIONAL WATERWAYS COMMISSION:

Your committee, which was appointed to investigate the advisability of locating a dam at the outlet of Lake Erie (as proposed by the Board of Engineers on Deep Waterways) and the maintenance and regulation of suitable levels on the other lakes in the Great Lakes system, now has the honor to report upon these subjects. It is hoped that this investigation will be of assistance to the Commission in considering the subjects mentioned above.

THE GREAT LAKES.

1. The Great Lakes, comprising Lakes Superior, Michigan, Huron, Erie, and Ontario, situated between the United States and Canada, differ from the high seas in that the latter have diurnal tides while the former have periodic and seasonal stage cycles. Lake Superior, the largest of these lakes, has a length, from Duluth to Point Iroquois, of 383 miles and a breadth of approximately 160 miles. Its maximum recorded depth is 1012 feet. The outlet of this lake is the St. Marys River. The length of Lake Michigan is approximately 321 miles; its breadth, 118 miles, and its maximum measured depth 870 feet. Lake Huron is about 220 miles long and 101 miles wide, with a maximum measured depth of 750 feet. Lakes Michigan and Huron are connected by the Strait of Mackinac, and their outlet is the St. Clair River. Lake St. Clair is approximately 26 miles long and 24 miles wide; its maximum depth is less than 24 feet, except at the head of the Detroit River, the outlet of the lake. Lake Erie is about 240 miles in length, with a maximum width of 57 miles; its maximum depth, as recorded by the U. S. Lake Survey, is 210 feet. Niagara River is the outlet of this lake. Lake Ontario is about 190 miles long, 57 miles wide, and has a maximum recorded depth of 730 feet. The present natural outlet of this lake, as well as of the entire Great Lakes system, is the St. Lawrence River.

AREAS OF THE SEVERAL LAKES AND WATERSHEDS OF THE GREAT LAKES SYSTEM.

2. The areas of the surfaces of the Great Lakes and their watersheds, as detemined by the United States Lake Survey, are shown in Table 1.

TABLE 1.

LAKE.	Area of Lake Surface in Square Miles.	Drainage Area, Including Lake Surface in Square Miles.	Ratio of Lake to Land Area.
Superior	32,000	76,134	1: 1.37
Michigan	22,336	65,799	1: 1.95
Huron	22,978	72,008	1: 2.13
Michigan-Huron	45,314	137,807	1: 2.04
St. Clair	503	6,194	1: 11.31
Erie	9,968	34,573	1: 2.47
Ontario	7,243	32,980	1: 3.55

Authority: 1906 United States Lake Survey report. (Unpublished).

3. The land area for any watershed is considered as the difference between the total drainage area and the area of the lake surface. The areas of the small lakes and streams are taken as a part of the land area.

4. The ratio of lake to land area is least for Superior and greatest for St. Clair, and increases with each succeeding lake lower in the system, St. Clair excepted.

WATER-LEVEL RECORDS OF THE GREAT LAKES AND THEIR CONNECTING RIVERS.

5. Beginning about 1860 and continuing to date, daily or tri-daily water-level observations have been taken on the several lakes and connecting channels of the Great Lakes. These readings have been reduced to monthly mean stage by determining the average for the month. In 1899, the first self-registering automatic gages, giving a continuous graphical record of the rise and fall of the water, were installed. The water-level records tabulated in this report pertain directly to the stage of the waters of the Great Lakes system. In nearly every instance, they have been placed at the service of the Commission through the Chief of Engineers' reports, or have been obtained from the United States Lake Survey.

6. MARQUETTE. The elevation of the water surface of Lake Superior above mean tide at New York was observed at Superior, Wis., for the period from 1860 to 1871, inclusive, while from 1872 to 1907, inclusive, it was observed at Mar-

quette, Mich. The self-registering gage, located at Marquette, was placed in operation in November, 1902. During the forty-eight years of observations, there were months when no records were taken. For the years 1860 and 1861, missing values have been supplied by adding (algebraically) to the observed reading of the following or preceding month the monthly mean rise or fall of water surface from 1860 to 1871, inclusive. Missing values in the period from 1871 to 1888, inclusive, have been supplied by adding to Sault Ste. Marie, Mich., readings the monthly mean fall from Marquette to Sault Ste. Marie for that period. Missing values for the period from 1889 to 1901, inclusive, have been supplied from the Sault Ste. Marie readings by applying to these readings the monthly mean fall from Marquette to Sault Ste. Marie for that period. The stage of Lake Superior, from 1860 to 1907, inclusive, at Marquette, Mich., and Superior, Wis., is given in Table 2.

7. Sault Ste. Marie. The monthly mean stage of the St. Marys River, the outlet to Lake Superior, was observed at the southwest pier, Sault Ste. Marie, Mich., (above the locks) from November, 1870, to December, 1907, inclusive. Before November, 1899, the readings were taken with a staff gage, but since that time a self-registering gage has been in operation. To make the records complete from January, 1860, to October, 1870, inclusive, the mean monthly fall from 1871 to 1888, inclusive, from Marquette to Sault Ste. Marie, has been subtracted from the corresponding Marquette readings. These monthly mean stages at Sault Ste. Marie (above the locks) are given in Table 3.

8. Milwaukee. The water-level records giving the stage of water of Lake Michigan, from 1860 to 1907, inclusive, were taken at Milwaukee, Wis. The monthly mean elevations of water surface are given in Table 4.

9. Harbor Beach. From September, 1874, to December, 1907, inclusive, the stage of Lake Huron was observed at Harbor Beach, Mich., (formerly Sand Beach). From April, 1901, to December, 1907, inclusive, the stage was recorded by a self-registering gage. The water levels from January, 1860, to August, 1874, inclusive, were derived by the United States Lake Survey, (see page 4105, appendix EEE, annual report of the Chief of Engineers for 1904), as follows: January, 1860, to September, 1864, inclusive, from observations at Point aux Barques; and October, 1864, to August, 1874, inclusive, from observations at Port Austin. These water

levels for Lake Huron stage, from 1860 to 1907, inclusive, are given in Table 5.

10. G. T. R. Water-level observations have been taken near the head of the St. Clair River, at G. T. R. (Grand Trunk Railway) from March, 1899, to December, 1907, inclusive. The computed G. T. R. monthly mean gage readings from January, 1860, to February, 1899, inclusive, were derived from the relation deduced between the monthly mean stage at Harbor Beach and Grand Trunk Railway, from March, 1899, to December, 1904, inclusive. The equations are: for assumed open season, from April to December, (G. T. R.—578)=0.889 (Harbor Beach—578)—0.529, and for the winter season of January, February and March, (G. T. R.—578)=0.889 (Harbor Beach—578)—0.235. The actual observations showed that during the average open season the fall from Harbor Beach to G. T. R. remained practically constant for the same stage, but increased slightly with increasing stages of Lake Huron, while during the winter months the fall decreased materially but also increased slightly with increasing stages of the lake. The G. T. R. gage data are shown in Table 6.

11. St. Clair Flats Canal. In July, 1872, the first authentic records of the stage of Lake St. Clair were taken at the St. Clair Flats Canal. These readings were recorded continuously up to December, 1907, inclusive, with the exception of October, 1877; April and May, 1878; June, 1879, to August, 1881, inclusive; November, 1881, to April, 1882, inclusive; June, September, and October, 1882; December, 1882, to April, 1883, inclusive; January to March, 1902, inclusive; February to April, 1903, inclusive; January, 1906, to October, 1906, inclusive; and August, 1907, to December, 1907, inclusive. From January, 1860, to June, 1872, inclusive, no observations were taken. Values for the missing monthly mean water levels at St. Clair Flats Canal for January, 1861, to July, 1865, inclusive; January, 1866; April and May, 1878, and June, 1879, to August, 1881, inclusive, have been deduced from the monthly means of observations taken simultaneously at St. Clair Flats Canal, the Light-house Depot, Detroit, Mich. (see 1868, United States Lake Survey report in report of the Secretary of War, Fortieth Congress, third session, Vol. 2, 1868-69, p. 985), and Amherstburg, Ont., from which the derived relation between fall from Light-house Depot to Amherstburg, and fall from St. Clair Flats to Amherstburg has been determined. The equation expressing this relation is: (Fall St. Clair Flats to Amherstburg)=1.0357 (Fall Light-house Depot to

Amherstburg)+0.377. Those missing for January, 1868, to March, 1868, inclusive; January, 1869, to March, 1869, inclusive; December, 1869, to March, 1870, inclusive; January and February, 1871; and December, 1871, to March, 1872, inclusive, have been derived from the monthly means of observations taken simultaneously at St. Clair Flats Canal, Old Detroit Waterworks, located at the foot of Orleans Street, Detroit, Mich. (see Forty-ninth regular report of the Board of Water Commissioners to the Common Council of the city of Detroit, 1901), and Amherstburg, Ont., from which has been derived the relation between the fall from St. Clair Flats to Old Detroit Waterworks, and fall from St. Clair Flats to Amherstburg. The derived equation is: (Fall St. Clair Flats to Amherstburg)=0.9378 (Fall Old Detroit Waterworks to Amherstburg)+0.853. Those missing for August, 1865, to December, 1865, inclusive; February, 1866, to December, 1867, inclusive; April, 1868, to December, 1868, inclusive; April, 1869, to November, 1869, inclusive; April, 1870, to December, 1870, inclusive; March, 1871, to November, 1871, inclusive; April, 1872, to June, 1872, inclusive; and October, 1877, have been derived independently from Light-house Depot observations and from Old Detroit Waterworks' records taken at the foot of Orleans Street, Detroit, Mich., as previously explained. The mean of the two derived values has been used for St. Clair Flats. For all months of the year 1860, the St. Clair Flats values (as given on p. 4097, United States Lake Survey report of 1904) have been reduced by 0.67 foot, so as to obtain the original readings taken as the Old Detroit Waterworks, foot of Orleans Street, which were not available. From the original readings thus obtained, new values for stage at St. Clair Flats Canal have been derived by the fall method previously described. The value 0.67 foot represents the mean fall from St. Clair Flats Canal to Old Detroit Waterworks, as deduced on p. 4082 of the United States Lake Survey report for 1904. The derived values for November, 1881, to April, 1882, inclusive; June, September, and October, 1882; and December, 1882, to April, 1883, inclusive, have been obtained by first subtracting 0.48 foot (0.477) from the New Detroit Waterworks' readings and then applying the mean monthly fall from St. Clair Flats to New Detroit Waterworks, as deduced from observations taken at those points from January, 1889, to June, 1901, inclusive. The value referred to above (0.48 foot) represents the discrepancy in the elevation of the zero of the New Detroit Waterworks' gage, as determined about 1878 and during the period from 1893 to

1897. In the forty-ninth regular report of the Board of Water Commissioners of Detroit, it was assumed that the error occurred when the gage was moved and that it had remained at a constant elevation from January, 1878, until 1893. A comparison of these data with those taken simultaneously at St. Clair Flats Canal indicates that the change occurred after May, 1889. Those for January to March, 1902, inclusive; February to April, 1903, inclusive; January to October, 1906, inclusive; and August to December, 1907, inclusive, have been derived from the observations taken at Windmill Point, Lake St. Clair, by applying the mean monthly fall from St. Clair Flats Canal to Windmill Point, as determined from simultaneous observations taken at those points from January, 1897, to July, 1907, inclusive. The monthly mean levels of Lake St. Clair, at St. Clair Flats Canal, are given in Table 7.

12. Windmill Point. Water-level readings have been taken at Windmill Point, near the outlet of Lake St. Clair, by the United States Lake Survey, from 1897 to 1907, inclusive, with the exception of February, 1898, and May and June, 1902. The monthly mean stage values from January, 1860, to December, 1896, inclusive, and for the three missing months mentioned above, have been derived from the St. Clair Flats Canal readings by applying to those values the mean monthly fall from St. Clair Flats Canal to Windmill Point, as determined from simultaneous observations made at those points from January, 1897, to July, 1907, inclusive. The monthly mean values at Windmill Point are given in Table 8.

13. Amherstburg. For several years, commencing with July, 1899, water-surface readings have been taken at the foot of the Detroit River, by which a good relation has been obtained between the water levels at Cleveland, Ohio, and Amherstburg, Ont. The values from January, 1860, to June, 1899, inclusive, and July to December, 1907, inclusive, were derived by applying to the Cleveland, Ohio, readings the mean monthly fall from Amherstburg to Cleveland, as determined from stimultaneous observations at those places from July, 1899, to December, 1904, inclusive. The Amherstburg monthly mean water-surface readings are shown in Table 9.

14. Cleveland. Water-level readings of Lake Erie have been taken at Cleveland, Ohio, from 1860 to 1907, inclusive, with the exception of January, 1877, and October, 1880, to March, 1881, inclusive, which values have been supplied by applying to the monthly mean values for Erie, Pa., the corresponding yearly mean difference of stage between Erie and

Cleveland. The values from January, 1860, to December, 1903, inclusive, have been taken from the United States Lake Survey report for 1904, beginning with p. 4097. Those from January, 1904, to December, 1907, inclusive, have been taken from the United States Lake Survey annual reports. These monthly mean water levels of Lake Erie, at Cleveland, Ohio, are given in Table 10.

15. BUFFALO. All of the water-surface records taken at Buffalo, prior to March, 1887, were accidently destroyed, and values have been derived from Cleveland readings by applying to such readings the mean monthly fall from Cleveland to Buffalo, as derived from simultaneous observations taken at those places from June, 1899, to December, 1906, inclusive. Values for January and February, 1901, and December, 1902, have been supplied in the same way. From 1888 to 1898, inclusive, the monthly means have been derived from the U. S. Lake Survey tables by subtracting 0.1 foot from the records there given. This correction has been determined by a comparison with Cleveland of the mean of the three months, June, July, and August, for each year during this period. From March, 1899, to December, 1907, inclusive, the gage records have been taken with a self-registering automatic gage, located at the Buffalo Breakwater Light-house. The monthly mean elevations of Lake Erie, at Buffalo, N. Y., from 1860 to 1907, inclusive, are given in Table 11.

16. CHARLOTTE. Water-level readings of Lake Ontario have been taken at Charlotte, N. Y., from January, 1860, to October, 1907, inclusive. In 1906, the United States Lake Survey's automatic gage was destroyed and since that time has not been replaced. These monthly mean water-surface elevations of Lake Ontario at Charlotte, N. Y., are given in Table 12.

17. OSWEGO. Water-level observations have been taken at Oswego, N. Y., from 1860 to 1907, inclusive. These water levels give the true elevations of Lake Ontario for that period, with the possible exception of some spring months when the Oswego River is at flood stage. These water-surface elevations of Lake Ontario, at Oswego, N. Y., are given in Table 13.

18. OGDENSBURG. The water-level records of the St. Lawrence River, taken at Ogdensburg, N. Y., are very incomplete. The missing monthly means for Ogdensburg have been derived from Oswego readings by use of the following equation, which has been derived from monthly mean levels at those two places, as deduced from simultaneous observations: (Og-

densburg—240)=0.9426 (Oswego—240)—0.553. The St. Lawrence River water levels, at Ogdensburg, are shown in Table 14.

19. Lock 27. The Canadian Government has observed the stage of water on the sills of the several locks in the St. Lawrence canals for many years. The observations taken at Lock 27, which is located at the head of Galop Rapids in the St. Lawrence River, date from January, 1875, and are complete to December, 1907, inclusive, with the exception of June, 1878, February, 1880, and August and September, 1890, the values for which have been derived from Oswego values, using the following formula: (Lock 27—240)=0.9457(Oswego —240)—1.845. For the period from January, 1860, to December, 1874, inclusive, the water-level values have been derived from Oswego, N. Y., readings according to the above formula, which assumes a mean-fall relation between Oswego and Lock 27 during that period. Table 15 gives the monthly mean water-level records of the St. Lawrence River, at Lock 27, head of Galop Rapids, from 1860 to 1907, inclusive.

20. Lock 24. The water-level readings taken at Lock 24 have been observed from January, 1880, to December, 1907, inclusive, and are complete with the exception of February, 1880, April and May, 1882, and May, 1890. Lock 24 is located at the head of the Morrisburg Canal. This canal was built along a portion of the north shore of the St. Lawrence River, and provides a 14-foot navigable channel around the Rapide Plat. Table 16 gives the monthly water levels at Lock 24, head of Rapide Plat, St. Lawrence River, from January, 1880, to December, 1907, inclusive.

21. Lock 21. The stage observations taken at Lock 21, the upper entrance to the Cornwall Canal and at the head of the Long Sault Rapids in the St. Lawrence River, were begun January, 1870, and are complete to December, 1907, inclusive, with the exception of September, 1882. The monthly mean water-surface readings at Lock 21, Cornwall Canal, head of Long Sault Rapids, St. Lawrence River, are given in Table 17.

22. Plate 1 shows the monthly mean stage of Lakes Superior, Michigan-Huron, St. Clair, Erie, and Ontario from 1860 to 1907, inclusive.

NOMENCLATURE.

23. The following abbreviations and terms are used in this report.

S = Total supply to any lake, in cubic feet per second.

R = Run-off from watershed, in cubic feet per second.

D = Discharge of lake's outlet, in cubic feet per second.

E = Evaporation from lake surface, in cubic feet per second.

P = Precipitation on lake surface, in cubic feet per second.

I = Inflow or transmitted supply from lake above, in cubic feet per second.

L = Local supply, or supply from lake's own drainage area, in cubic feet per second.

s = Storage on lake surface, in cubic feet per second, (positive or negative).

A = Area of lake, in square feet.

h = Depth, in feet, on lake surface, measured from any datum.

t = Time, in seconds, for one-twelfth of a year.

i = Increment, or rate of change of discharge in cubic feet per second per foot change in stage.

u = Coefficient.

g = Acceleration due to gravity, = 32.2 feet per second per second.

b = Width of section, or length of crest of submerged weir in feet.

h_U = Head, in feet, on crest of submerged weir, measured from upstream side.

h_D = Head, in feet, on crest of submerged weir, measured from down-stream side.

F = Fall in stream, expressed in feet.

C = Coefficient.

V = Mean velocity, in feet per second.

k = Theoretical velocity head, in feet, = $V^2 \div 2g$.

h_s = Height of swell, in feet.

d = Mean depth, in feet.

$R_{MAX.}$ = Ratio between the maximum value of mean monthly discharge and the maximum value of mean monthly total supply of any lake.

$T_{MAX.}$ = Time interval in days between the date of the occurrence of the maximum value of mean monthly total supply to any lake and that of the maximum value of mean monthly discharge from that lake.

$T_{MIN.}$ = Time interval in days between the date of the occurrence of the minimum value of mean monthly total supply to any lake and that of the minimum value of mean monthly discharge from that lake.

GENERAL EQUATION FOR STREAM FLOW.

24. The discharge equations of all rivers in the Great Lakes system, with the exception of the St. Marys River, have been derived by use of a submerged-weir formula. Each river bed has been assumed to represent a submerged weir with a broad, flat crest, whose upstream and downstream faces are of considerable length. The location of the submerged weir has been assumed to be at or near the critical cross section, which is generally at the head of the river. The submerged-weir formula is generally recognized in one of the following two forms:

$$D = u\frac{2}{3}b\sqrt{2g}\,(h_U - h_D)^{\frac{3}{2}} + ubh_D\sqrt{2g}\,(h_U - h_D)^{\frac{1}{2}} \quad (1)$$

$$D = u\frac{2}{3}b\sqrt{2g}\,\left(h_U + \frac{h_D}{2}\right)(h_U - h_D)^{\frac{1}{2}} \quad (2)$$

where h_U represents the depth on the average elevation of the crest of the weir, measured from the upstream side,
h_D the depth on the average elevation of the crest of the weir, measured from the downstream side, and
b, the length of the weir crest in feet. The quantity, (h_U—h_D), represents the fall (F) in the stream, or the difference between the upstream and downstream heads. The quantity, $u2/3b\sqrt{2g}$, taken as a whole, represents a variable coefficient (C) which has been derived for each river and is applicable only to that river. This submerged-weir formula reduces to the form,

$$D = CF^{\frac{1}{2}}\left(h_U + \frac{h_D}{2}\right) \quad (3)$$

and was so used in deriving the discharge equations of the several rivers. For every measurement of river discharge, all factors are known with the exception of the coefficient, which has been derived. Knowing the way in which the coefficient for each river varies according to the upstream and downstream head, it is a comparatively simple matter to compute the discharges of the several outlets according to the proper formula. On the St. Clair, Detroit, and St. Lawrence Rivers, the coefficients vary as a function of the upstream and downstream head on the submerged weir. The curve used, showing the manner in which C varies, is the equilateral hyperbola, with its asymptotes parallel to the co-ordinate axes. It is:

$$C = \frac{y}{1 + \frac{x}{h_U}} \quad (4)$$

in which C is the coefficient depending on h_U or h_D, the upstream or downstream head, respectively.
x and y are constants, which represent the distance of the asymptotes from the y and x axes, respectively.
For convenience in deriving the unknown values, this hyperbolic equation has been transformed into a straight-line equation by dividing by y, which gives

$$C = \frac{1}{\frac{1}{y} + \frac{x}{yh_v}} \qquad (5)$$

and then taking the reciprocal of each member:

$$\frac{1}{C} = \frac{1}{y} + \frac{x}{y}\left(\frac{1}{h_v}\right) \qquad (6)$$

DISCHARGE OF ST. MARYS RIVER, OUTLET TO LAKE SUPERIOR.

25. The Marys River, from Point Iroquois, in Lake Superior, to the head of the United States Ship Canal, at Sault Ste. Marie, Mich., is a wide stream with comparatively little slope, there being about two-tenths of a foot fall in this distance. At the latter location, rapids (about one-half a mile in length) connect the upper and lower St. Marys River. The submerged weir of rock at the head of these rapids controls the discharge of water from Lake Superior, and any change in this submerged weir would cause a change in the volume of discharge for the same stage. Any auxiliary channel connecting with the pool immediately above the weir would increase the river discharge for the same stage by the volume thus diverted. During the epoch, 1860 to 1907, inclusive, the regimen of the St. Marys River, above the rapids, was changed on several occasions. In 1887 and 1888, the International Bridge across the St. Marys Rapids was constructed. Prior to that time, the river discharged at the bridge site through four channels, viz., the main rapids and three small streams situated between the islands lying adjacent to the north shore. The building of the bridge piers and approaches and the filling in of portions of the three small streams (called *a*, *b*, and *c*) on the north side of the main channel reduced the effective area at this critical discharge cross section so that the flow of the St. Marys River was materially decreased.

26. In 1889, the Canadian Water Power Company (now the Lake Superior Power Company) commenced work on a power plant and used for its canal the northerly of the three small streams (*c*) previously mentioned. The flow therein was practically stopped until the latter part of 1895, when this power plant was opened. During the year 1892, the Edison Sault Electric Light & Power Company (now the Chandler-Dunbar Water Power Company) built a dyke from the second pier on the American side of the International Bridge, parallel to the shore, for a distance of about 1,500

feet down the stream. The area inclosed by the American shore and this dyke is used as a forebay by the power company, practically shutting off from the main channel the flow through these two spans. By December, 1892, the flow of the river had been restricted by the building of the piers and approaches to the International Bridge, the shutting off of spans 1 and 2 from the main channel on the American side, and the closing of stream *c* on the Canadian side. Beginning in December, 1895, the Lake Superior Power Company started the operation of its plant on a large scale, using water at the rate of approximately 3800 cubic feet per second. This power plant has been in continuous operation since then, with the exception of February and March, 1896, and has gradually increased the quantity of water used until it now reaches about 6000 cubic feet per second. The use of water by the American and Canadian locks has also increased from time to time until it now amounts to an average flow of about 600 cubic feet per second. In 1901, the Michigan Lake Superior Power Company started work on the construction of a compensating works in the rapids of the St. Marys River, about 300 feet above the International Bridge. These works practically shut off the entire flow through spans 9 and 10, the first two spans on the Canadian side of the river. In January, 1905, the Michigan Lake Superior Power Company began to divert water through its canal, using about 8500 cubic feet per second at that time.

27. DISCHARGE MEASUREMENTS. During the winter of 1896, discharge measurements of the St. Marys River were taken by the United States Government at Spry's Dock Section, located about a mile below the St. Marys Rapids. The discharge equation deduced from these observations, modified for the various efflux conditions, has been the governing factor for the determination of the outflow of Lake Superior from January, 1860, to September, 1901, inclusive. The derived equation is:

$$D_{RIVER}=18826\ (\text{Southwest Pier Gage}-600)+37060. \quad (7)$$

See 1906 United States Lake Survey report (unpublished).

28. The Southwest Pier Gage is located at the southwest pier above the American locks at Sault Ste. Marie, Mich. At the time that these measurements were taken, the Chandler-Dunbar Water Power Company was using 1065 cubic feet of water per second through its works; streams *a* and *b* on the north side of the main channel were still open, and the Lake Superior Power Company's plant was closed.

29. In 1902, the United States Lake Survey measured the flow through the St. Marys Rapids at the International Bridge, which connects Sault Ste. Marie, Mich., with Sault Ste. Marie, Ont. The discharge equation derived from these observations gives the flow through the rapids after spans 9 and 10 (the first two spans on the Canadian side) were closed by the construction of the compensating works of the Michigan Lake Superior Power Company. It is:

$D_{RAPIDS} = 15540$ (Southwest Pier Gage—600) + 30510. (8)

30. During February and March, 1905, observations of the flow in the St. Marys River were taken at "Section Brewery," located about 2000 feet below the Spry's Dock Section. The discharge equation derived from these measurements is:

$D_{RIVER} = 18484$ (Southwest Pier Gage — 600) + 41829. (9)

This formula gives the total flow of the river, while that derived from the 1902 measurements gives only the flow through the St. Marys Rapids.

31. ST. MARYS RIVER DISCHARGE FORMULAE, AS USED FOR THE DIFFERENT EFFLUX CONDITIONS. The discharge formula governing the first period, 1860-1888, inclusive, was derived from the measurements made in 1896 and 1902 (the fifth and tenth periods of efflux) in conjunction with hydraulic data taken at the International Bridge Section in 1901 and 1902. The mean stage of the St. Marys River at the Southwest Pier (above the locks), Sault Ste. Marie, Mich., from 1871 to 1905, inclusive, was 601.86 feet above mean tide at New York. The 1896 discharge measurements give: $D_{RIVER} = 18826$ (Southwest Pier Gage — 600) + 37060. The discharge of the river at mean stage was 72076 cubic feet per second. Deducting from this value 1065 cubic feet per second (the amount of water used by the Chandler-Dunbar Water Power Company) and 1798 cubic feet per second (the discharge of two small streams on the north side of the rapids) gives the flow through the main channel of the St. Marys Rapids as 69200 cubic feet per second. From the vertical and transverse percentage velocity curves deduced from observations made at the Bridge Section, for spans 3-10, inclusive, in 1901, and for spans 3-8, inclusive, in 1902, the ratio of flow of the entire cross section to that for any partial section has been determined. These curves show the modification in the transverse velocity curve due to the construction, by the Michigan Lake Superior Power Company, of the compensating works located about 300 feet above the bridge. With these data, the transverse percentage velocity curve at the International Bridge Section, for the first period, has been constructed for the entire main channel,

which included the channels for spans 1 and 2 of the bridge, next the American shore. This curve has been integrated and its mean ordinate, or mean percentage velocity, computed. The product of this value and the mean velocity of the rapid's flow at mean river stage under the 1896 conditions, or during the fifth period of efflux, gives the mean velocity for the main channel under the original conditions, or for the first period of efflux. The product of the mean velocity and the area of the cross section before the bridge was built gives the discharge of the main channel for mean river stage. The equations giving the actual computations are:

$$D_1 = A_1 \left(\frac{D_5}{A_5} \times \text{mean percentage } V_1\right) = A_1 V_1 \qquad (10)$$

$$= 13690\left(\frac{69200}{10650} \times 0.925\right) = 13690 \times 6.01 = 82280$$

cubic feet per second, discharge of main channel for mean river stage under original conditions.

32. With the volume of flow known for mean river stage, the only remaining step is to derive the increment of discharge per foot change in stage. In deriving this increment, use has been made of Bernouilli's theorem applied to open channels with steady flow, expressed as follows:

$$\text{Friction head} = F + \frac{V^2_{\text{UPSTREAM}}}{2g} - \frac{V^2_{\text{DOWNSTREAM}}}{2g} \qquad (11)$$

33. It has been assumed that the friction heads before and after the rise were proportional to the squares of the respective velocities at the Bridge Section. The two cross sections used are: The upper one, located nearly opposite the Southwest Pier Gage, and the lower one, at the International Bridge. Under original conditions, the areas of the upper and lower cross sections were 46260 and 13690 square feet, respectively, and the width were 3400 and 2383 feet, respectively, at 601.86 feet, the mean river stage at Southwest Pier Gage. According to formula 10, the discharge of the river at this stage was 82280 cubic feet per second. The corresponding mean water surface at the Bridge Section was 600.56 feet. Substituting these values in the preceding formula gives: Friction head before rise=1.30+0.049—0.562=0.787 foot. Actual measurements taken under the conditions existing for the fifth and tenth periods show that a rise of 1 foot at Southwest Pier Gage for mean river stage caused a rise of 0.636 and 0.592 foot at the bridge, respectively. These are the values for rise before and after the

compensating works had been constructed. The mean of the above values (0.614 foot) has been used as the assumed rise under original conditions, since the relation appeared to be nearly constant for two radically different discharge periods. After a rise of 1 foot at the upstream section, the mean velocity became $\frac{D}{49660}$ feet per second, and the corresponding velocity head was $\frac{(\frac{D}{49660})^2}{2g}$. For the rise of 0.614 feet at the downstream section, the mean velocity became $\frac{D}{15150}$ feet per second, and the corresponding velocity head was $\frac{(\frac{D}{15150})^2}{2g}$. The potential head after rise was: $F=1.30+1.00-0.614=1.686$ feet. Substituting the new values in Bernouilli's formula gives: Friction head after rise $= 1.686+ \frac{(\frac{D}{49660})^2}{2g} - \frac{(\frac{D}{15150})^2}{2g}$. Under the previous assumption that the friction heads before and after the rise were proportional to the square velocities, we have:

$$0.787 : 1.686 + \frac{(\frac{D}{49660})^2}{2g} - \frac{(\frac{D}{15150})^2}{2g} :: 6.01^2 : (\frac{D}{15150})^2 \qquad (12)$$

whence D=103840 cubic feet per second. This value represents the discharge through the main channel at 1 foot above mean river stage, 601.86. The difference between this discharge value and 82280, the discharge for mean stage, is 21560 cubic feet per second, the increment of discharge for 1 foot rise above mean stage. This method was also used for the determination of the increment for one foot below mean stage, which gave 20720. The mean of 21560 and 20720, viz., 21140 cubic feet per second, has been used as the increment of discharge.

34. The discharge formula governing the flow through the main channel for the period is as follows:

$D_{1\ \text{MAIN CHANNEL}}=21140$ (Sou't west Pier Gage—601.86)+ 82280. (13)

35. The two small streams (*a* and *b*) situated on the north side of the main channel had a flow of 1800 cubic feet per second at mean river stage, with an estimated increment of discharge per foot rise of 950 cubic feet per second. The

third small stream (*c*) situated also on the north side of the main channel had an estimated flow of 1800 cubic feet per second at mean river stage, with an estimated increment of discharge per foot rise of 950 cubic feet per second. By combining the above results, the discharge formula of the St. Marys River for the original conditions, or first period, (January, 1860, to November, 1888, inclusive), before any alterations had occurred in the outlet to Lake Superior above the St. Marys Rapids, is:

$D_1 = 23040$ (Southwest Pier Gage — 601.86) + 85880. (14)

36. The construction of any engineering structure necessarily takes time; so, in the building of the piers and approaches for the International Bridge, some time elapsed before the completion of the substructure. It is assumed that original conditions prevailed to December 1, 1888, after which the piers and approaches for the International Bridge are considered as having been completed, and stream *c*, adjacent to the north shore, as having been closed. This date marks the beginning of the second period, which is assumed to continue to December, 1892, inclusive. The discharge formula governing the flow through the main channel for this efflux condition has been computed in the same way as that for the first period. It is:

$D_{2\ \text{MAIN CHANNEL}} = 19080$ (Southwest Pier Gage—601.86)+ 77200. (15)

37. Two small streams (*a* and *b*) situated on the north side of the main channel were still flowing, as in the first period. Combining the results of the flow through the main channel and streams *a* and *b* gives the total flow in the St. Marys River for the second period as:

$D_2 = 20030$ (Southwest Pier Gage—601.86)+79000. (16)

38. For the third period, January, 1893, to November, 1895, inclusive, the efflux condition was the same as that for February and March, 1896, when the discharge measurements were taken. It is assumed that the Chandler-Dunbar Water Power Company closed spans 1 and 2, on the American end of the International Bridge, at the beginning of this period. The volume of water used by them was estimated to be about 1065 cubic feet per second. Streams *a* and *b* were still flowing. The equation of discharge for St. Marys River for the third efflux condition is:

$D_3 = 18826$ (Southwest Pier Gage—600)+37060. (17)

39. In December, 1895, the beginning of the fourth period, the Lake Superior Power Company began using water on a large scale, estimated by the chief engineer of the Lake

Superior Power Company at 3800 cubic feet per second. The Chandler-Dunbar Water Power Company is assumed to have been still using 1065 cubic feet per second. Streams *a* and *b* were still flowing. The discharge equation for the fourth period, from December, 1895, to January, 1896, inclusive, is:

D_4=18826 (Southwest Pier Gage—600)+40860. (18)

40. The fifth epoch, February and March, 1896, marks the date of the first discharge measurements of the St. Marys River used in this report. The discharge formula for the river flow is:

D_5=18826 (Southwest Pier Gage—600)+37060. (19)

41. For the sixth period, April, 1896, to December, 1897, inclusive, the auxiliary flow is estimated at 3500 cubic feet per second through the works of the Lake Superior Power Company. Streams *a* and *b* were still open. The Chandler-Dunbar Water Power Company was using approximately 1065 cubic feet per second. The three latter are included in the river discharge formula as derived from observations made in February and March, 1896. The discharge equation of the St. Marys River for this period is:

D_6=18826 (Southwest Pier Gage—600)+40560. (20)

42. For the seventh period, January, 1898, to March, 1899, inclusive, 4000 cubic feet per second is estimated as the side flow through the works of the Lake Superior Power Company. Streams *a* and *b* were still flowing. The Chandler-Dunbar Water Power Company is estimated to have been still using about 1065 cubic feet per second. The discharge through the locks for this period and previous thereto has not been incorporated in the discharge equations, owing to the fact that it is considered to have been, comparatively, a small quantity. The discharge equation giving the flow of the St. Marys River for this period is:

D_7=18826 (Southwest Pier Gage—600)+41060. (21)

43. For the eighth period, April, 1899, to December, 1899, inclusive, the side flow through the works of the Lake Superior Power Company is estimated at 4000 cubic feet per second. Streams *a* and *b* were still flowing. The Chandler-Dunbar Water Power Company is assumed to have increased its flow at the beginning of the period from 1065 cubic feet per second to 1400 cubic feet per second. It is estimated that the American and Canadian locks were using at that time an average flow of 600 cubic feet per second. By combining the above data, the net side flow, other than that at the time of the 1896 discharge measurements,=4000+(1400—1065)+600=4935 cubic feet per second, (4940 used). The discharge

formula for the St. Marys River for this period is:

$D_9 = 18826$ (Southwest Pier Gage $- 600) + 42000$. (22)

44. For the ninth period, January, 1900, to September, 1901, inclusive, streams *a* and *b* are assumed to have been closed at the beginning of the epoch. The shutting of these two channels decreased the increment of discharge per foot rise by 950 cubic feet per second, or to 17880, but did not change the total discharge for the main channel at stage 600 on account of the discharge of streams *a* and *b* being approximately zero at this stage. The side flow through the works of the Lake Superior Power Company is estimated to have been 5000 cubic feet per second. The Chandler-Dunbar Water Power Company and the American and Canadian locks are assumed to have been using 1400 and 600 cubic feet per second, respectively. By combining the above data, the net side flow of the river, other than that at the time of the 1896 measurements, was: $5000 + (1400 - 1065) + 600 = 5935$ cubic feet per second, (5940 used). The discharge formula for the St. Marys River for this period is:

$D_9 = 17880$ (Southwest Pier Gage—600)$+43000$. (23)

45. For the tenth period, October, 1901, to December, 1904, inclusive, the discharge formula derived from the measurements taken at the International Bridge in 1902, after the compensating works had been constructed by the Michigan Lake Superior Power Company, is:

$D_{10\ \text{MAIN CHANNEL}} = 15540$ (Southwest Pier Gage—600)$+ 30510$. (24)

46. This equation represents the flow through the St. Marys Rapids and does not take into account the flow through the Chandler-Dunbar Water Power Company's forebay and plant. Previous to this period, the quantity of water used by the Chandler-Dunbar Water Power Company is considered directly in the discharge equation. The side flow through the works of the Lake Superior Power Company is estimated to have been 5000 cubic feet per second. The Chandler-Dunbar Water Power Company and the American and Canadian locks are estimated to have been using about 1400 cubic feet per second and 600 cubic feet per second respectively. The discharge formula of the St. Marys River, used for this efflux condition, is:

$D_{10} = 15540$ (Southwest Pier Gage—600)$+37510$. (25)

47. For the eleventh period, January, 1905, to December, 1907, inclusive, the discharge formula depends on discharge measurements made by the United States Lake Survey in February and March, 1905, at "Section Brewery," located

about 2000 feet below Spry's Dock Section, which was situated opposite the power house belonging to the Michigan Lake Superior Power Company. During this period, the side flow through the works of the Lake Superior Power Company, the Michigan Lake Superior Power Company, the Chandler-Dunbar Water Power Company, and the American and Canadian locks is estimated at 6000, 8500, 1400, and 600 cubic feet per second, respectively. The discharge formula giving the total flow of the river for this period, based on the 1905 measurements, is:

D_{11}=18484 (Southwest Pier Gage—600)+41830. (26)

48. It has been noted that the discharge formula for efflux periods 10 and 11 show a difference in the increment of discharge of 2944 cubic feet per second for substantially the same conditions, the only known change in the regimen being an assumed constant diversion of 8500 cubic feet per second through the canal of the Michigan Lake Superior Power Company. This difference in increment is probably due in part to greater leakage at high stage through the dam of the Chandler-Dunbar Water Power Company.

49. The following table gives a summary of the discharge equations for the St. Marys River for the several efflux periods:

TABLE 18.

SUMMARY OF ST. MARYS RIVER DISCHARGE EQUATIONS FOR THE DIFFERENT EFFLUX CONDITIONS.

No. of Period.	Length of Period.	Discharge Equation, St. Marys River.
1	Jan. 1860—Nov. 1888	D_1 = 23040 (Southwest Pier Gage — 601.86)+33330
2	Dec. 1888—Dec. 1892	D_2 = 20030 (Southwest Pier Gage — 601.86)+79000
3	Jan. 1893—Nov. 1895	D_3 = 18426 (Southwest Pier Gage — 600.00)+37000
4	Dec. 1895—Jan. 1896	D_4 = 18526 (Southwest Pier Gage — 600.00)+36800
5	Feb. 1896—Mar. 1896	D_5 = 18826 (Southwest Pier Gage — 600.00)+37080
6	Apr. 1896—Dec. 1897	D_6 = 18826 (Southwest Pier Gage — 600.00)+40500
7	Jan. 1898—Mar. 1899	D_7 = 18826 (Southwest Pier Gage — 600.00)+41000
8	Apr. 1899—Dec. 1899	D_8 = 18826 (Southwest Pier Gage — 600.00)+42000
9	Jan. 1900—Sep. 1901	D_9 = 17880 (Southwest Pier Gage — 600.00)+43000
10	Oct. 1901—Dec. 1904	D_{10} = 15540 (Southwest Pier Gage — 600.00)+37510
11	Jan. 1905—Dec. 1907	D_{11} = 18484 (Southwest Pier Gage — 600.00)+41830

Southwest Pier Gage gives the elevation of the water surface of St. Marys River at Southwest Pier, above the locks, Sault Ste. Marie, Mich., above mean tide at New York.

50. The monthly mean discharge values of the St. Marys River, from January, 1860, to December, 1907, inclusive, are given in Table 19.

51. Probable Effect Upon Mean Level of Lake Superior of Obstructions in St. Marys River at Head of Rapids. Any obstruction placed in a river at or near its critical or con-

trolling discharge section changes the volume of flow and affects the level of the lake above and also the levels of those below. The construction of the piers and approaches of the International Bridge changed the discharge of the river and raised the mean level of Lake Superior. The shutting off of spans 1 and 2 on the American side, from the main channel, by the Chandler-Dunbar Water Power Company, and the construction of the compensating works by the Michigan Lake Superior Power Company have also had their effect on the level of Lake Superior and the lower lakes. The ultimate effect of these obstructions placed in the main channel has been derived for mean river stage on the assumption that no diversions have been made by the Lake Superior Power Company or the Michigan Lake Superior Power Company. This maximum effect on lake levels has not entirely taken place, owing to these diversions by the said power companies. In treating this subject, use has been made of the incomplete-weir formula, river-discharge increments and river-gage relations. The discharge through the main channel of the St. Marys Rapids for the third to ninth periods, inclusive, for mean river stage at Southwest Pier Gage, (1871 to 1905, inclusive,) 601.86, has been previously computed as 69200 cubic feet per second. The corresponding measured mean water surface at the International Bridge Section during this period of flow was 600.61. In 1902, after the compensating works of the Michigan Lake Superior Power Company were built, practically closing spans 9 and 10, the mean water surface of this section was measured as 600.98 for the same discharge, 69200 cubic feet per second. This rise of 0.37 foot in the water surface represents the swell, h_s, at the International Bridge Section, due to the shutting off by the compensating works of the two spans on the Canadian side of the rapids. These actual measurements afford a means for determining an experimental value of u in the incomplete-weir formula.

$$D = ub\sqrt{2g}\left\{\frac{2}{3}\left[(h_s+k)^{\frac{3}{2}}-k^{\frac{3}{2}}\right]+d\,(h_s+k)^{\frac{1}{2}}\right\}. \qquad (27)$$

where D=69200 cubic feet per second, the discharge through the St. Marys Rapids, in third to ninth periods, inclusive, with mean water surface at International Bridge of 600.61, and in tenth period with mean water surface of 600.98, b_A= 1511 feet, width of channel after obstruction by compensating works,

2g=64.4 feet per second per second,

h_s=height of swell, in feet.

$k = \frac{V^2}{2g} = \frac{(D/A_B)^2}{2g} =$ 0.655 foot=theoretical velocity head previous to placing of obstruction, and where A_B is area of cross section of main channel before compensating works were built=10650 square feet.

$d = \frac{A_B}{b_B} = \frac{10650}{1794} =$ 5.937 feet=mean depth previous to construction of works, where b_B is width of channel in third to ninth periods, inclusive. Substituting these values in the above equation and solving gives a value for u of 0.899. The building of the piers and approaches of the International Bridge, according to computations, reduced the discharge through the main channel from 82280 to 77200 cubic feet per second, decreased the channel width from 2383 to 2232 feet, and changed the cross-sectional area from 13690 to 12490 square feet. Substituting these values in the incomplete-weir formula and using the experimental value of u (0.90) gives the swell, h_s, at the bridge site, due to the construction of the piers and approaches, as 0.183 foot. The corresponding rise at Southwest Pier was 0.298 foot. This latter value represents the estimated rise in mean lake level caused by the building of the International Bridge. About four years after the International Bridge was built, the Chandler-Dunbar Water Power Company shut off spans 1 and 2, on the American side, from the main channel. This obstruction reduced still more the mean discharge through the main channel. Using the incomplete-weir formula.

$$D = ub\sqrt{2g}\left\{\frac{2}{3}\left[(h_s+k)^{\frac{3}{2}}-k^{\frac{3}{2}}\right]+d(h_s+k)^{\frac{1}{2}}\right\}$$

for determining the effect of building the bridge piers and approaches and closing spans 1 and 2, where D = 82280 cubic feet per second, discharge at mean river level, 601.86, under original conditions,

u=0.90, experimental coefficient for present case,

b_A=1794 feet, width of channel after obstructions were built,

2g=64.4 feet per second per second,

$k = \frac{V^2}{2g} = \frac{(D/A_B)^2}{2g} =$ 0.562 feet, theoretical velocity head previous to placing of obstructions, where A_B is area of cross section of main channel before structures were placed =13690 square feet.

$d = \frac{A_B}{b_B}$ =5.745 feet=mean depth before structures were placed, whereb_B=2383 feet,
and solving for h_s gives 0.496 foot as the swell at the Bridge Section due to the construction of these works. The discharge formula for the flow through the main channel of the rapids, after the bridge piers and approaches were built and spans 1 and 2 were closed, according to 1896 measurements, is: $D_{RAPIDS\ 3-9}$=17880 (Southwest Pier Gage—600.00) +35995, while that after the compensating works were built, according to the 1902 measurements, is: $D_{RAPIDS\ 10}$=15540 (Southwest Pier Gage—600.00)+30510. The increment at Southwest Pier Gage, as determined in 1896 and 1902, is 17880 and 15540, respectively, while that at the Bridge Section for the 1896 conditions was unknown, and for 1902 was 22600. In order to determine the increment at the bridge, under the 1896 conditions, the assumption has been made that the increments of discharge per foot rise under the same efflux conditions are directly proportional for various points in a stream. This proportion is; Increment Southwest $Pier_{10}$: increment Southwest Pier $_{3-9}$ :: increment $Bridge_{10}$: increment $Bridge_{3-9}$ or, inserting values, 15540 : 17880 :: 22600 :X. Solving: X=26000. The difference between the discharge through the main channel in the rapids for the first period and the third-ninth period is 82280—69200=13080 cubic feet per second. This quantity represents the volume of water cut off by the construction of the bridge piers and approaches and closing of spans 1 and 2. Since 1 foot rise at the bridge, under original conditions, is equivalent to an increase in discharge of 26000, then the swell caused by these obstructions, involving a reduction in discharge of 13080 cubic feet per second, is =0.503 foot. The swell at the bridge, due to the building of the piers and approaches for the International Bridge, the shutting off of spans 1 and 2 by the Chandler-Dunbar Water Power Company, and the closing of spans 9 and 10 by the construction of the compensating works, computed by the incomplete-weir formula, is 0.817 foot. Subtracting 0.37 foot, the actual measured swell due to the building of the Compensating works, gives 0.447 foot as the swell at the Bridge Section due to the building of the piers and approaches of the International Bridge and the shutting off of spans 1 and 2.

52. Summarizing: The swell at the Bridge Section, due to the construction of the piers and approaches and shutting off of spans 1 and 2, is:

Incomplete weir, (direct)	0.496 foot
Increment	.503 foot
Incomplete weir, (indirect) 0.817 — 0.370	.447 foot
Mean swell	.482 foot

53. The above value represents the swell at the bridge due to these obstructions, but it does not represent the true effect on the St. Marys River at Southwest Pier. Since the increment of discharge at Southwest Pier is 17880, the swell at that point, due to decreasing the discharge through the rapids by 13080, is $\frac{13080}{17880}$ =0.732 foot. By water-surface relations between Southwest Pier and mean water surface at Bridge, it is found that for mean river stage (601.86) at Southwest Pier, the corresponding mean water surface at Bridge is 600.613. Adding 0.482 foot, the mean swell at the bridge due to the construction of the piers and approaches and shutting off the spans 1 and 2, gives 601.095 as the new mean water surface. The gage readings as Southwest Pier, corresponding to this mean water surface at the bridge, is 602.645. The difference between 602.645 and 601.86 is 0.785, the swell due to building these obstructions.

54. Summarizing: The swell at Southwest Pier, due to building the piers and approaches for the International Bridge and shutting off of spans 1 and 2, is:

Increment method	0.732 foot
Gage relations	.785 foot
Mean	.758 foot

55. During the period immediately following the building of the compensating works, the mean water surface at the Bridge Section was 600.54 for mean river stage. The rapid's discharge, corresponding to this gage height, was 59300 cubic feet per second. The difference between the mean rapid's discharge before and after the building of these works is computed to be 69200—59300=9900 cubic feet per second. The increment of discharge at the bridge, as determined by measurement, was 22600. From these data, the swell at the bridge is computed to be $\frac{9900}{22600}$ =0.439 foot. Actual measurements taken before and after the compensating works were built give the swell at the bridge as 0.37 foot.

56. Summarizing: The swell at the Bridge Section, due to the construction of the compensating works, is:

Increment (direct)	0.439 foot
Actual measurement	.370 foot
Incomplete weir (indirect, 0.817 — 0.482)	.335 foot
Mean	.381 foot

57. The swell at the Southwest Pier for this period, computed by the increment method, is =0.638 foot, while by gage relations it was 0.648 foot. The mean of these two values gives 0.643 foot as the rise in the mean river stage at the southwest pier, due to the compensating works.

58. SUMMARY. The mean stage of St. Marys River at the southwest pier, from 1871 to 1905, inclusive, is 601.86. The effect of the building of the piers and approaches to the International Bridge and the shutting off of spans 1 and 2 on the American shore by the Chandler-Dunbar Water Power Company was to raise the mean river level at the Southwest Pier 0.758 foot, or to an elevation of 602.618. The effect of the construction of the compensating works on the mean river level at Southwest Pier was to raise it 0.643 foot, or to a new mean river stage of 603.261. The mean water surface at the International Bridge, after the compensating works were built, corresponding to 603.261 at Southwest Pier, was 601.423 feet. Subtracting from this value the swell at the bridge, due to the compensating works namely, 0.381 foot, gives the mean water surface at the bridge, before the compensating works were built, as 601.042. Subtracting from this new value 0.482 foot, the swell at the Bridge Section due to the construction of the piers and approaches to the International Bridge, and the shutting off of spans 1 and 2 from the main channel, gives 600.56 as the original mean water surface at the Bridge Section. The effect of placing obstructions in the St. Marys River at or near the International Bridge site has been to raise the mean level of the river at the bridge and Southwest Pier, and also the mean level of Lake Superior. If no diversions from the upper river had occurred, the ultimate rise in the mean level of the St. Marys River and Lake Superior would have been approximately 1.40 feet; but, owing to diversions having taken place, this rise has been diminished.

ST. CLAIR RIVER DISCHARGE.

59. During the period from April, 1899, to September, 1902, inclusive, the United States Lake Survey measured the discharge of the St. Clair River, the outlet to Lake Huron,

in the vicinity of Port Huron, Mich. These measurements have been used in deriving a formula for the flow of this river in terms of G. T. R. and Dry Dock gage heights. The elevation of the crest of the submerged weir has been assumed at 543 feet above mean sea level. The St. Clair River discharge formula, as derived, is:

$$D = \left(\frac{C_{G.T.R.} + C_{D.D.}}{2}\right) F^{\frac{1}{2}} \left(h_U + \frac{h_D}{2}\right) \qquad (28)$$

in which the coefficients depending on the stage at G. T. R. and Dry Dock, derived from the discharge measurements, are:

$$C_{G.T.R.} = \frac{2700.316}{\frac{62.872}{h_U} - 1}, \text{ and } C_{D.D.} = \frac{2766.21}{\frac{61.982}{h_D} - 1}, \text{ respectively.}$$

60. This discharge equation of the St. Clair River, depending on the gage readings at G. T. R. and Dry Docks, has been transformed to one depending on G. T. R. and St. Clair Flats, on account of the long series of readings taken at the St. Clair Flats Canal. In order to substitute the St. Clair Flats Canal readings for Dry Dock readings in the discharge formula, the following equation was used: (Fall, G. T. R. to St. Clair Flats Canal)=7.4482 (Fall G. T. R. to Dry Dock)—1.9657. The St. Clair River discharge formula, as transformed, is:

$$D = \frac{C_{G.T.R.} + C_{ST.\ CLAIR\ FLATS\ CANAL}}{2} F^{\frac{1}{2}} \left(h_U + \frac{h_D}{2}\right). \qquad (29)$$

The coefficients derived in this transformed equation are:

$$C_{G.T.R.} = \frac{1308.339}{\frac{64.674}{h_U} - 1}, \text{ and } C_{ST.\ CLAIR\ FLATS\ CANAL} = \frac{1445.118}{\frac{59.123}{h_D} - 1}.$$

61. This last equation, expressed in terms of St. Clair Flats and G. T. R., has been used to compute the mean discharges of St. Clair River from 1860 to 1907, inclusive.

62. In 1900, the Chicago Drainage Canal began deverting water from Lake Michigan. The quantity used from 1900 to June, 1904, inclusive, has been computed from data furnished the Commission by the United States Engineer Office at Chicago. The flow through the canal for the last half of the year 1904, and 1905, 1906, and 1907, has been assumed to be the quantity authorized in the permit of the Secretary of War.

DETROIT RIVER DISCHARGE.

63. The Detroit River discharge equation has been derived from measurements taken at Fort Wayne, Mich., by the United States Lake Survey during the summers of 1901 and 1902. The elevation of the crest of the weir is assumed as 540 feet above mean sea level. A part of these observations were rejected owing to the fluctuation in the level of water at Amherstburg during the discharge measurement. The remaining discharges were used in determining the discharge equation. The discharge formula, as derived, is:

$$D_{\text{DETROIT}} = \frac{C_{\text{W.PT.}} + C_{\text{AM H.}}}{2} F^{\frac{1}{2}} \left(h_U + \frac{h_D}{2}\right). \qquad (30)$$

in which $C_{\text{W.PT.}}$ for the upstream head at Windmill Point $= \frac{11.745}{\frac{52.248}{h_U} - 1}$,

$C_{\text{AMH.}}$ for the downstream head at Amherstburg $= \frac{20.529}{\frac{60.083}{h_D} - 1}$,

F = fall, Windmill Point to Amherstburg,

h_U = upstream head on crest of submerged weir, determined by Windmill Point gage heights,

h_D = downstream head on crest of submerged weir, determined by Amherstburg gage heights.

64. Owing to the lack of sufficient observations, no winter discharge formula have been derived for the Detroit or St. Clair Rivers. It is, undoubtedly, true that for the same slope the discharge is less with an ice covering than without one, on account of the increased friction.

Ice gorges occur in the St. Clair and Detroit rivers nearly every winter, creating an abnormal slope in the river that is gorged. Under such conditions, the discharge value, computed from the river not gorged, has been used as the correct monthly mean inflow to Lake Erie.

65. The monthly mean discharge values of the Detroit River from January, 1860, to December, 1907, inclusive, are given in Table 20.

NIAGARA RIVER DISCHARGE.

66. The discharge of the Niagara River has been determined by measurements taken at the International Bridge, located at Buffalo, N. Y., and at a point about 1800 feet down stream at the "Open Section." These observations were begun in 1897 under the direction of E. E. Haskell, Engineer for

the United States Deep Waterways Commission. At the conclusion of this work, the United States Lake Survey continued the measurements in 1898, 1899, and 1900. These measurements have been reduced on the assumption that the outlet of Lake Erie is a submerged weir witth a broad, flat crest, whose upper nappe is about one mile in length and the lower one about two, with the crest section at or near the Buffalo Waterworks' Intake Pier. The Niagara River discharge formula, as derived, is:

$$D_{NIAGARA} = CbF^{\frac{1}{2}}\left(h_U + \frac{h_D}{2}\right). \qquad (31)$$

in which F = fall from Buffalo Breakwater Light-house, in Lake Erie, to Austin Street, in Niagara River,
h_U = upstream head on crest of submerged weir, determined by Buffalo Breakwater Light-house gage,
h_D = downstream head on crest of submerged weir, determined by Austin Street gage,

$C = -0.02458h_U + 2.550.$

556.35 = the average elevation of the crest of the weir above mean tide at New York,
b = width of crest section, at Waterworks' Intake, which is determined as follows: Compute the mean fall in the Niagara River from Buffalo Breakwater Light-house to Austin Street, according to the formula, $F = 0.02976X^2 - 0.4896X + 6.5828$, in which X = Lake Erie stage at Buffalo Breakwater Light-house gage above elevation 560 feet. Substitute this value for fall, or the actual fall between these two points in the equation, (Fall, Buffalo Breakwater Light-house to Waterworks' Intake = 0.4916 (Fall, Buffalo Breakwater Light-house to Austin Street) + 0.6553, and solve for fall from Buffalo Breakwater Light-house to Waterworks' Intake Section. Determine the corresponding stage of water at Waterworks' Intake Section by subtracting the fall from Buffalo Breakwater Light-house to Waterworks' Intake Section from Lake Erie stage as measured at Buffalo Breakwater Light-house. Then substitute in the equation, b = 80 (Waterworks' Intake stage above mean tide at New York) — 43598, and solve for the width of the crest section.

The monthly mean discharge values of the Niagara River, from January, 1860, to December, 1907, inclusive, are given in Table 21.

ST. LAWRENCE RIVER DISCHARGE.

67. The St. Lawrence River discharge formula has been determined from discharge measurements made by the United States Lake Survey in 1901 and 1902 at "Three Points Section," situated about 15 miles below Ogdensburg, N. Y., and 9 miles below the head of the Galop Rapids. During the measurements, no simultaneous gage readings were observed at Lock 27. Since the discharge equation is expressed in terms of Ogdensburg and Lock 27 gage heights, the latter have been computed for each measurement according to the equation, (Ogdensburg — 240) = 0.0006489 (Lock 27 — 240)^2 + 0.97085 (Lock 27 — 240) + 1.3502, which was derived from simultaneous monthly mean readings taken at the two places. This method was deemed most accurate, for, during the months when observations were taken, the slope between Ogdensburg and Lock 27 approximated very closely the mean slope computed by the above formula. It has been assumed that the submerged weir lies between Ogdensburg and Lock 27, near the head of the Galop Rapids, and the mean elevation of the crest of this weir is 230 feet above mean sea level at New York. The discharge equation, as deduced for summer flow, May to November, inclusive, before the Gut channel at the Galop Rapids was closed, is:

$$D_{\text{(summer) St. Lawrence}} = \frac{C_{oo} + C_{27}}{2} F^{\frac{1}{2}} \left(h_u + \frac{h_d}{2}\right). \quad (32)$$

in which C_{oo}, for the upstream head measured at Ogdensburg self-registering gage, is $= \frac{114430.485}{\frac{152.389}{h_u} + 1}$,

C_{27}, for the downstream head, measured at Lock 27, is $= \frac{54507.508}{\frac{59.445}{h_d} + 1}$,

F = fall, Ogdensburg to Lock 27,

h_u = upstream head on crest (elevation 230) of submerged weir, determined by Ogdensburg gage height,

h_d = downstream head on crest (elevation 230) of submerged weir, determined by Lock 27 gage height.

68. The slope in the river from Oswego and Ogdensburg to Lock 27, increases in the winter, due to the ice covering, which causes increased friction with the water and decreases the discharge for a given stage. The average increase in fall for the winter season, between Lock 27 and Ogdensburg, has

been determined as 0.31 foot. For any given stage at Lock 27, with mean summer slope to Ogdensburg, the discharge of the St. Lawrence River can be derived by formula (32). With this known river discharge and stage at Lock 27, and with Ogdensburg gage heights increased by 0.31 foot for average winter conditions, a solution for C in the submerged-weir formula has been made. This operation was repeated so as to cover the range in stage at these two gages.

69. The winter discharge equation, as deduced, covering the period from December to April, inclusive, and before the Gut channel at the Galop Rapids was closed, is:

$$D_i \text{ (WINTER) ST. LAWRENCE} = \frac{C_{oo.} + C_{27}}{2} F^{\frac{1}{2}} \left(h_U + \frac{h_D}{2}\right), \quad (33)$$

in which $C_{oo.}$, for the upstream head, measured at Ogdensburg self-registering gage in the winter season, is $= \frac{131202.913}{\frac{206.737}{h_U}+1}$,

C_{27}, for the downstream head, measured at Lock 27 in the winter season, is $= \frac{53597.993}{\frac{67.401}{h_D}+1}$,

F = fall, Ogdensburg to Lock 27,
h_U = upstream head on crest (elevation 230) of submerged weir, determined by Ogdensburg gage heights,
h_D = downstream head on crest (elevation 230) of submerged weir, determined by Lock 27 gage heights.

70. As previously stated, the winter months have been considered as December to April, inclusive. During many of these months, ice gorges have occurred in the river, above the Galop Rapids, which conditions have invalidated the winter-slope relation and caused abnormally high discharge values. Fortunately, below the Galop there are two more submerged weirs, one at the head of Rapide Plat, near Lock 24 on the Morrisburg Canal, and the other at the head of the Long Sault Rapids, near Lock 21 on the Cornwall Canal, at which points water-level observations have been made by the Canadian Government for many years.

71. Owing to lack of data, the Commission has been unable to derive a submerged-weir formula for the St. Lawrence River discharge based on the stage of water at the Rapide Plat and Long Sault Rapids, and has used the overfall-weir formula derived by the United States Lake Survey for these two locations, and has also used in a few instances the over-

fall-weir formula in terms of Lock 27, when ice gorges occurred at Lock 24 and Lock 21 and the slope in the river above the Galop was abnormal.

72. These discharge equations for the St. Lawrence River flow are:

$$D_{27\ \text{ST. LAWRENCE}} = 5732\ (2.80 + h_{27})^{\frac{1}{2}}, \tag{34}$$

$$D_{24\ \text{ST. LAWRENCE}} = 16.60\ (22.10 + h_{24})^{2.5}, \tag{35}$$

$$D_{21\ \text{ST. LAWRENCE}} = 316.0\ (8.30 + h_{21})^{2.3}, \tag{36}$$

where h_{27}, h_{24} and h_{21} are the gage readings above the old lock sill of each lock as zero.

73. In determining the monthly mean discharge of the St. Lawrence River for January, February, and March, from 1870 to 1907, inclusive, values have been deduced according to the submerged-weir and the three overfall-weir formulae. The minimum result in each case has been used as the most reliable value.

74. In 1903, the Canadian Government began work on closing the Gut channel, the smallest of the three channels at the head of the Galop Rapids. The damming of this outlet decreased the discharge of the St. Lawrence River for any given stage. According to the United States Lake Survey, this change in flow has been about 5½ per cent. less than that for the assumed original condition, January, 1860, to August, 1903, inclusive. This percentage change has been applied to the discharge equations for the period previous to September, 1903, and other discharge formulae deduced.

75. The formula as derived for summer conditions of flow of the St. Lawrence, after the Gut channel was closed, is:

$$D_{2\ (\text{SUMMER})\ \text{ST. LAWRENCE}} = \frac{C_{os.} + C_{27}}{2}\ F^{\frac{1}{2}}\left(h_v + \frac{h_o}{2}\right) \tag{37}$$

in which C for the upstream head, measured at Ogdensburg self-registering gage, is: $C_{os.} = \dfrac{104112.068}{\dfrac{146.326}{h_v} + 1}$,

C for the downstream head, measured at Lock 27, is:

$$_{27} = \frac{55685.721}{\dfrac{65.075}{h_p} + 1},$$

F = fall from Ogdensburg self-registering gage to Lock 27,
h_o = upstream head on crest (elevation 230) of submerged weir, determined by Ogdensburg gage heights,

h_D = downstream head on crest, determined by Lock 27 gage heights.

76. The St. Lawrence River winter discharge formula, after the Gut channel was closed, as deduced, is:

$$D_2 \text{ (WINTER) ST. LAWRENCE} = \frac{C_{og.} + C_{27}}{2} F l \left(h_v + \frac{h_D}{2}\right). \quad (38)$$

in which C for Ogdensburg self-registering gage is:

$$C_{og} = \frac{135093.09}{\frac{226.492}{h_v} + 1},$$

C for Lock 27 is: $C_{27} = \frac{52177.516}{\frac{69.799}{h_D} + 1}$.

The remaining factors are the same as for summer flow.

The monthly mean discharge values of the St. Lawrence River, from January, 1860, to December, 1907, inclusive, are given in Table 22.

DISCHARGE INCREMENTS OF THE RIVER OUTLETS OF THE GREAT LAKES SYSTEM.

77. The discharge increment, or rate of change of river flow per unit change in stage, varies in the several river outlets of the Great Lakes. It is not only different for each river but it also changes with the section and the stage. In general, the increment at mean stage increases with each river lower in this series. The Detroit River increment is greater than the St. Clair; likewise, the St. Lawrence River increment is greater than the Niagara. It also increases as each river is descended. On the Niagara River, the increment at Buffalo Light-house, Buffalo, for mean stage of Lake Erie, is 23400 cubic feet per second per foot, while at Grass Island, near the intake of the Niagara Falls Power Company, at Niagara Falls, N. Y., the increment is about 43000 cubic feet per second per foot. There are exceptions to this rule when the river section is contracted. At the head of the Whirlpool Rapids, in the Niagara River, a contracted section reduces the increment to about 9000 cubic feet per second per foot. In the St. Lawrence River, contracted sections occur at the head of the Rapide Plat and the head of the Long Sault Rapids. At the former, the increment is about 22500 cubic feet per second per foot, while at Lake Ontario it is 28100 cubic feet per second per foot. Table 23 gives the discharge increments, expressed in cubic feet per second per foot change in stage, of the several river outlets of the Great Lakes.

TABLE 23.

INCREMENTS OF DISCHARGE OF THE SEVERAL RIVER OUTLETS OF THE GREAT LAKES, EXPRESSED IN CUBIC FEET PER SECOND PER FOOT CHANGE IN STAGE.

River.	Location of Gage.	Stage.	Increment.
St. Marys.....	Sault Ste. Marie, Mich.,	601.91 (Mean)	18,500
		601—602	18,500
		602—603	18,500
St. Clair.....	Harbor Beach, Mich.,	581.44 (Mean)	18,900
		579—580	16,300
		580—581	17,500
		581—582	19,100
		582—583	20,900
Detroit.....	Windmill Point, Mich.,	575.40 (Mean)	20,600
		574—575	18,300
		575—576	20,900
		576—577	22,500
Niagara.....	Buffalo, N. Y.,	572.67 (Mean)	23,400
		570—571	19,600
		571—572	21,400
		572—573	23,200
		573—574	25,100
St. Lawrence....	Ogdensburg, N. Y.,	245.28 (Mean)	28,100
		244—245	26,800
		245—246	27,600
		246—247	29,300
		247—248	29,800

SUPPLY FACTORS OF GREAT LAKES.

78. The total supply (S) of water to a reservoir or lake depends on the inflow (I) or transmitted supply from another watershed, the precipitation (P) on the surface of the lake, the run-off (R) from the lake's watershed, and evaporation (E) from the lake's surface; or the outflow or discharge (D) from and storage (s) in the lake. Of these factors, for the Great Lakes, the transmitted supply (I), the discharge (D), and the storage (s), are known singly, while the value of precipitation (P), run-off (R), and evaporation (E), is known collectively.

79. The following equation expresses the total supply to any lake:

$$S = I + R + P - E = D \pm s. \qquad (39)$$

Now, $s = Ah$, where A is the area of the lake and h the depth in feet above any datum. Transposing and substituting in (39) the value of s, we have:

$$S - D = Ah \qquad (40)$$

80. The following equation shows the rate of change in the depth (dh) at any instant of time (dt):

$$(S - D)\,dt = A\,dh \tag{41}$$

Integrating with respect to t and h between the limits o and t and o and h, respectively, we have:

$$(S - D)\int_o^t dt = A\int_o^h dh \tag{42}$$

$$(S - D)\,t = Ah \tag{43}$$

81. An inspection of equation (43) shows that when S is greater than D the lake surface is rising and the storage is increasing, when S is less than D the lake surface is falling and the storage is decreasing; and when S is equal to D the lake surface remains at the same level and there is no change in the storage.

82. The local supply (L) to a reservoir or lake has been assumed as the water-yield from its own watershed. It is also, in a series of connecting watersheds, equal to the total supply (S) minus the transmitted supply or inflow (I) from the watersheds situated above.

83. The following equation expresses the local supply to any lake:

$$L = S - I = (D \pm s) - I = R + P - E \tag{44}$$

84. The known supply factors have been deduced for Lakes Superior, Michigan-Huron, Erie, and Ontario for the period of 48 years, from 1860 to 1907, inclusive. These results are shown in Tables 24, 25, 26, and 27, and Plates 2-17, inclusive.

85. For Lake Superior, the water levels at Marquette, Mich., have been assumed to represent the mean lake surface, and those at Sault Ste. Marie, Mich., (above the locks) have been used in computing the discharge of the lake's outlet. The stage readings on the first of the month for this lake and those lower in the series have been interpolated from the monthly mean readings. For Lake Michigan-Huron, the mean of the stage values for Milwaukee, Wis., and Harbor Beach, Mich., has been used for the mean lake surface. Lake St. Clair has been treated as a part of the Michigan-Huron watershed, and the Detroit River, as the natural lake outlet. Since 1900, water has been diverted from Lake Michigan through the Chicago Drainage Canal. The St. Clair River is the outlet to Lake Michigan-Huron, but, owing to the apparent changes in regimen prior to the first accurate discharge measurements in

1899, it became necessary to eliminate this river and use the Detroit, regardless of the fact that there have been many more discharge measurements of the St. Clair. The regimen of the Detroit River has, apparently, remained nearly constant during the period from 1860 to 1907, inclusive. For Lake Erie, the water levels at Cleveland, Ohio, have been used to represent the mean lake surface, and those at Buffalo, N. Y., to govern the outflow through the Niagara River. The volume of water diverted from the natural outlet of Lake Erie through the Erie and Welland canals has been estimated at 1000 and 1100 cubic feet per second, respectively. These amounts, added to the Niagara River discharge values represent the total outflow from Lake Erie. For Lake Ontario, the Oswego, N. Y., stage readings have been assumed to represent the mean water level of the lake. During periods in the spring, when the Oswego River was at flood stage, these water levels may be slightly in error. The outflow through the St. Lawrence River has been derived from the values of the Ogdensburg and Lock 27 gage heights, used collectively, except as heretofore noted.

86. Lake Superior Supply Factors. An inspection of Plates 2-5, inclusive, shows that Lake Superior had a maximum monthly mean stage of 604.08, in September, 1869, and a minimum of 600.76, in February, 1871. During the high water of 1876, Superior rose, in August, to 603.93. On several occasions, the lake level has fallen to about 601.0, or lower, as in 1879, 1880, 1892, and 1893. Since 1894, Superior has fluctuated between 601.46 and 603.54, a range of 2.08 feet, while the maximum fluctuation since 1860 has been 3.32 feet. The mean water level for the 48 years, 1860 to 1907, inclusive, was 602.32. The storage capacity of Superior is enormous, one foot depth on the lake surface being equivalent in volume to a constant inflow of 340100 cubic feet per second for one month. During the period which this investigation covers, the storage has been over + 200000 cubic feet per second, for a month, on several occasions. In May, 1876, May, 1888, and May, 1899, Superior stored + 207500, + 212600, and + 204100 cubic feet per second, respectively. In August, 1869, the lake stage increased 0.655 foot, equivalent to + 222800 cubic feet per second storage. The occurrence of the maximum storage in the month of August is most unusual. At other times, the lake surface has fallen almost as rapidly. In November, 1869, November, 1870, December, 1870, December, 1871, and December, 1897, the storage was — 168400, — 188800, — 173400, — 161600, and — 137700 cubic feet per second, respectively. The corresponding feet depths on lake surface are: — 0.495,

— 0.555, — 0.510, — 0.475, and — 0.405. For the three months of November and December, 1870, and January, 1871, Lake Superior fell from 602.47, on November 1st, to 601.06, on February 1st, a storage of — 1.41 feet. The outflow from Lake Superior through the St. Marys River has not shown the fluctuations so noticeable in the storage. In September, 1869, the river discharged 128700 cubic feet per second, and in September, 1876, 121800 cubic feet per second. These two values represent the maximum monthly mean discharge to date. On only two occasions has the monthly mean discharge fallen below 50000 cubic feet per second, and that occurred during February and March, 1893, when it reached 48200 and 48400 cubic feet per second, respectively. The total monthly mean supply or water-yield to Lake Superior has ranged between 333300 cubic feet per second, in August, 1869, and — 106600, in December, 1870, equivalent to 0.980 and — 0.313 foot depth on lake surface, respectively. A maximum monthly mean supply of + 200000 cubic feet per second, or more, has occurred in 21 of the 48 years. A minus monthly mean supply has occurred in 42 of the 48 years. Minus values have occurred in each month between October and April, inclusive, although December has been the prevailing one.

87. Lake Michigan-Huron Supply Factors. As shown on Plates 6-9, inclusive, the monthly mean stage of Lake Michigan-Huron has fluctuated between 583.58 and 583.60, in July, 1876, and June, 1886, respectively, and 579.00, in December, 1895, a range of 4.6 feet. Previous to 1886, the lake level had fallen to about 580.2, or 1.2 feet above the low water of 1895 and 1896, on only three occasions, March, 1869, March, 1872, and January and February, 1873. Since September, 1890, the monthly mean stage has not exceeded 581.5, except in July and August, 1905, and July, 1907, when it was 581.56, 581.54, and 581.56, respectively. The mean stage of Lake Michigan-Huron for the 48 years, 1860 to 1907, inclusive, was 581.38. As previously stated, in Table 1, the area of Lake Michigan-Huron is 45314 square miles. An increase in depth of one foot on this surface is equivalent to a constant inflow of 480700 cubic feet per second for one month. The storage on this lake, in May, 1873, and May, 1876, amounted to + 251400 and + 254800 cubic feet per second, respectively, with corresponding depths on surface of 0.523 and 0.530 foot. A monthly storage of + 150000 cubic feet per second is quite common. Occasionally, the high rate of storage extends over several months, as in April, May and June, 1876, when the average monthly increase for this period had a value of + 220300,

equivalent to a total change in stage of + 1.37 feet in three months. On the other hand, when the lake stage had fallen, as in August, September, October, November, and December, 1871, the average monthly decrease in storage had a value of — 183600 cubic feet per second, equivalent to a total decrease in stage of 1.91 feet in the five months. The minimum storage occurred in September, 1871, when it had a value of — 261500 cubic feet per second, equivalent to a depth on lake of — 0.544 foot. Values of — 150000 to — 200000 cubic feet per second have occurred frequently. The outflow through the Detroit River has ranged from about 275400, in July, 1883, to 105300, in February, 1874. The discharge of this river is dependent not only upon the stage of Lake St. Clair but also upon the fall to Lake Erie. The stage of Lake St. Clair is, in turn, dependent on the discharge from Michigan-Huron and on its outflow to Erie. A large discharge from Michigan-Huron raises Lake St. Clair quickly, while a high stage of Erie decreases the discharge of the Detroit River and raises Lake St. Clair by backwater. An increasing stage of Lake St. Clair with constant fall to Erie, or an increasing fall with the same St. Clair stage, gives increased discharge through the Detroit River.

88. Lakes Michigan-Huron and Erie do not rise and fall simultaneously. In some cases, the former will be rising and the latter falling. This is usually what occurs during the winter months of January, February, and March, and sometimes in December, April, and May. Ice gorges in the St. Clair or Detroit River hold back the water, thus depleting the supply to Erie and storing it in Michigan-Huron. When the gorge occurs in the St. Clair River, Lake St. Clair falls and the slope to Lake Erie becomes less than normal and that to Michigan-Huron greater. When the gorge occurs in the Detroit River, Lake St. Clair rises and the slope to Michigan-Huron is less than normal and that to Erie greater. If ice gorges of the same intensity should occur in the St. Clair and the Detroit rivers simultaneously, Lake St. Clair would probably not indicate the gorged condition, since the discharge increments of the two rivers would be decreased and the lake would remain at its normal level. By an inspection of the hydrograph of the Great Lakes, as shown on Plate 1, the effect of ice gorges in the St. Clair and Detroit rivers is seen. Attention is called particularly to the following months as indicating large gorges in the St. Clair River: February, 1865; March, 1877; January, 1884; February, 1886; April, 1901, and February, 1902. In each case, the stage of Lake St. Clair dropped and Michigan-

Huron rose. Large ice gorges in the Detroit River occurred in January, 1870, December, 1876, December, 1880, January, 1889, and February, 1895. This fact is substantiated by the extreme rise in Lake St. Clair and by the fall in Lake Erie. The total monthly mean supply to Lake Michigan-Huron has fluctuated between + 470800 cubic feet per second, in June, 1883, and — 32000 cubic feet per second, in September, 1871, equivalent to a depth on the lake of + 0.979 and — 0.067 foot, respectively. In May, 1873, and May and June, 1876, the total supply exceeded + 450000 cubic feet per second. In 10 of the 48 years, the monthly supply has been over + 400000 cubic feet per second. Monthly values of + 350000 cubic feet per second have occurred in over 60 per cent. of the years. Other months show a total supply of less than + 25000 cubic feet per second in many of these years. In April and May, 1873, May, 1876, and June, 1883, the local supply to Michigan-Huron was + 373000, + 365100, + 356400, and + 389100 cubic feet per second, respectively, corresponding to depth on lake of 0.776, 0.759, 0.741, and 0.809 foot, respectively. In September, 1871, the lake lost by evaporation 125700 cubic feet per second more than the actual precipitation on the lake surface and run-off of the tributary watershed. During the months from August to December, inclusive, a minus local supply has been common, in some cases extending over several months. From August to December, 1894, inclusive, evaporation on the lake surface exceeded the precipitation on the lake surface and run-off from the tributary watershed, and the stage of Lake Michigan-Huron dropped 1.3 feet.

89. Lake Erie Supply Factors. The monthly mean stage of Lake Erie (see Plates 10-13, inclusive,) during the period covered in this report, has risen to 574.52, in June, 1876. The minimum stage occurred in February, 1902, when Erie fell to 570.63. During the latter month, an extensive ice gorge occurred in the St. Clair River, which explains the extreme low stage of Erie at that time. Prior to that time, the minimum stage of Erie occurred in November, 1895, when it fell to 570.70. The monthly mean level has fluctuated through an extreme range of 3.89 feet, while the annual mean oscillation in lake level has been 2.53 feet. The mean stage of Erie, from 1860 to 1907, inclusive, was 572.60. The amount of storage, for a rise of one foot in the level of Lake Erie, is equivalent to a flow of 105700 cubic feet per second for one month. On but one occasion has the storage exceeded + 100000 cubic feet per second. In April, 1873, it had a value of + 103600, equivalent to a depth on lake surface of 0.98 foot. During the month

of January, 1865, the storage reached a minimum of —52900 cubic feet per second, corresponding to —0.50 foot on lake surface. A value nearly as small as the latter occurred in November, 1903, when the storage had a value of —49700, equivalent to —0.47 foot. The maximum monthly mean discharge from Lake Erie, 257800 cubic feet per second, equivalent to a depth of 2.44 feet on Lake Erie, occurred in June, 1876. The minimum, 168700 cubic feet per second, equivalent to a depth of 1.60 feet on lake surface, occurred in March, 1896. Ice gorges in the Niagara River, apparently, have had comparatively little effect on the outflow from Lake Erie. The maximum total supply of +314700 cubic feet per second to Erie, corresponding to a depth of +2.98 feet on lake, occurred in April, 1861. Large positive total supply values occurred in April, 1862, April, 1873, March and April, 1876, and June, 1883. The values for the several months are: +307,400, +309700, +295600, +289000, and +290300 cubic feet per second, respectively. In 16 out of the 48 years, a total monthly means supply of +275000 cubic feet per second has been exceeded. During the five-month period from February to June, 1876, inclusive, Erie had a monthly mean total supply greater than +250000 cubic feet per second, and the stage increased 1.82 feet. At other times, the total supply has decreased to less than half the maximum. The minimum, +146900 cubic feet per second, occurred in October, 1891, and November, 1903. The supply was nearly as low in January, 1865, and October, 1895, with values of +149300 and +148500 cubic feet per second, respectively. The local supply to Erie, apparently, has been very much less than to the lakes above. In April, 1873, January and February, 1874, and May, 1892, it exceeded +100000 cubic feet per second by 10600, 3200, 21600, and 9200, respectively. Minus values occur very frequently. In many years, the last six months give a minus local supply. From June, 1884, to March, 1885, inclusive, a minus local supply occurred during the entire period with an average monthly value of —40400. During this period, the lake fell from 574.14, in June, to 571.92, in March, a change in stage of —2.22 feet. The minimum monthly local supply to Erie of —63600 cubic feet per second, corresponding to a depth on lake surface of —0.60 foot, occurred in December, 1871. From August to November, 1867, inclusive, the monthly local supply was —57700, —60500, —61700, and —56500 cubic feet per second, respectively. Collectively, these values are equivalent to a depth on Lake Erie of 2.23 feet. During September, October and November, 1874, large successive local supply values of

— 50600, — 56100, and — 51200 cubic feet per second, respectively, occurred, equivalent to a total depth on Lake Erie of 1.49 feet. For September, October, and November, 1884, the monthly local supply was — 53100, — 57500, and — 50600 cubic feet per second, respectively. These values are, collectively, equivalent to 1.52 feet depth on Lake Erie.

90. Lake Ontario Supply Factors. Referring to Plates 14-17, inclusive, the maximum stage of Lake Ontario occurred in May, 1870, when the lake level had a value of 248.95. In 1861, 1862, 1863, 1864, 1867, 1876, 1883, 1884, 1886, 1887, and 1890, the stage exceeded 248.00. In November, 1895, the lake level dropped to 243.41, which has been the minimum stage during the 48 years from 1860 to 1907, inclusive. In two other years, the stage has fallen below 244.00. This condition occurred in January, November, and December, 1896, and January and February, 1897. This monthly fluctuation of Ontario is greater than that in any of the other Great Lakes. The maximum range in stage is 5.54 feet. Ontario fell from 248.48, in June, 1867, to 244.51, in January, 1868, a change in level of 3.97 feet. The mean stage of Lake Ontario, for the period from 1860 to 1907, inclusive, was 246.19. A foot depth on Lake Ontario is equivalent to a monthly flow of 76800 cubic feet per second. During March and April, 1873, and March, 1904, the monthly storage equalled or exceeded one foot depth on the lake surface, with corresponding storage values of + 79900, + 96000, and + 76800 cubic feet per second, respectively. Twelve of the 48 years had a monthly storage of + 50000 cubic feet per second, or more. During October and November, 1867, the minus storage exceeded — 50000 cubic feet per second, the values being — 53800, and — 57600 cubic feet per second, respectively. The discharge of the St. Lawrence River shows an extreme variation of about 130 per cent. This change in flow is small compared with rivers not having immense storage reservoirs at their sources. The maximum flow has been computed at 351200 and 350500 cubic feet per second, and occurred in May, 1862, and May, 1870, respectively. These values may be slightly too great on account of floods in the Oswego River causing abnormal gage readings for lake stage. These maximum discharge values have been approached in June and July, 1870, when there was little likelihood of the stage being affected by these local floods. In these two months, the flow has been computed at 344100 and 343200 cubic feet per second, respectively. The minimum flow has approximated 155000 cubic feet per second. In February, 1875, March, 1900, and, February, 1902, the discharge was

157900, 156600, and 152200 cubic feet per second, respectively. These extreme low discharges have been caused by ice gorges in the river. The minimum outflow, not caused by ice gorges, occurred in December, 1895, and December, 1896, when the discharge was 162500 and 164800 cubic feet per second, respectively. The total supply to Ontario has fluctuated between the maximum of + 382400 cubic feet per second, in April, 1870, and the minimum of + 154100 cubic feet per second, in February, 1875, a range of 228300 cubic feet per second. The equivalent depths on lake surface are 4.98 and 2.01 feet, respectively. In May, 1861, and April, 1862, the total supply was + 377400 and + 375600 cubic feet per second, respectively. Values of 325000 cubic feet per second have occurred in 17 of the 48 years. Since May, 1893, the total monthly supply has exceeded + 300000 cubic feet per second in but two years, 1903 and 1904. In 10 of the 48 years, the yield, or total supply, varied between + 155000 and + 175000 cubic feet per second during some months of the winter season. The Ontario local supply had a maximum of + 151800 cubic feet per second, in April, 1870. In January, 1881, the minimum value of — 34300 cubic feet per second occurred. In 7 years, the monthly mean local supply exceeded + 125000 cubic feet per second. In 17 of the 48 years, it exceeded + 100000 cubic feet per second. Minus values occurred frequently. The prevailing months for such values have been November, December, January, and February, although a minus local supply has occurred during all the months from August to February, inclusive.

MEAN MONTHLY SUPPLY FACTORS OF GREAT LAKES.

91. The mean monthly supply factors covering the period from 1860 to 1907, inclusive, have been derived from the monthly mean supply values of the several lakes for the 48-year period. Table 28 and Plate 18 give the results in numerical and graphical form. These curves show the mean monthly condition on Lakes Superior, Michigan-Huron, Erie, and Ontario. From Plate 18, Table 29 has been compiled, which shows the approximate date of maximum and minimum mean monthly values of stage, storage, outflow, total supply, and local supply of Lakes Superior, Michigan-Huron, Erie, and Ontario.

TABLE 29.

DATE OF MAXIMUM AND MINIMUM VALUES OF MEAN MONTHLY SUPPLY FACTORS OF THE GREAT LAKES.

LAKE.	Stage.	Storage.	Outflow.	Total Supply.	Local Supply.
Superior, maximum	Sep. 20	May 20	Sep. 1	May 25	May 25
Superior, minimum	Mar. 20	Dec. 10	Mar. 15	Dec. 15	Dec. 15
Michigan-Huron, maximum	Jul. 20	May 5	Aug. 1	May 10	May 5
Michigan-Huron, minimum	Feb. 1	Nov. 1	Feb. 20	Nov. 10	Oct. 25
Erie, maximum	Jun. 25	Apr. 5	Jul. 5	Apr. 20	Apr. 5
Erie, minimum	Feb. 10	Oct. 1	Feb. 20	Oct. 10	Oct. 1
Ontario, maximum	Jul. 1	Apr. 5	Jul. 1	May 5	Apr. 25
Ontario, minimum	Dec. 10	Sep. 5	Feb. 10	Jan. 20	Sep. 25

92. The mean monthly stage cycle on Lake Superior has fluctuated between 602.79, in September, and 601.77, in March, a change of 1.02 feet. A plus storage has occurred during the months of April to September, inclusive, while a minus storage has occurred during the months of October to March, inclusive. The maximum mean monthly storage has been 95900 cubic feet per second, while the minimum has been —91100. The discharge, or outflow, has increased from March 15th to September 1st, while it has decreased from September 1st to March 15th. The mean monthly outflow has ranged between 92800 and 68000 cubic feet per second. The total supply has increased values from December to May, and has decreased values from May to December. The mean monthly total supply has had a maximum value of 175700 cubic feet per second, and a minimum value of —10700 cubic feet per second. This minus value, which occurs in December, shows conclusively that the evaporation from Superior may be greater than the precipitation on lake surface and run-off from its watershed. The mean monthly supply, to Superior, in January, has been only 2300 cubic feet per second, which proves that evaporation on lake surface is nearly equal to the precipitation on lake surface and run-off from the tributary watershed for that month.

93. The mean monthly stage of Lake Michigan-Huron has fluctuated between 581.90, in July, and 580.93, in January and February, a range of 0.98 foot. The storage on Michigan-Huron has been positive from February to July, inclusive, while it has been negative from August to January, inclusive. The maximum and minimum mean monthly storage values have been +132300 and —112200 cubic feet per second, respectively. The mean monthly outflow through the Detroit River has fluctuated from 219700, in August, to 175600 cubic

feet per second, in February. This minimum discharge value is probably too large. The mean monthly total supply has had a maximum value of + 337700 cubic feet per second, in May, and a minimum value of + 96200, in November. The mean monthly local supply to Michigan-Huron has fluctuated between + 257800 cubic feet per second, in May, and + 8200 cubic feet per second, in October. During October and November, the local supply has been so small that the evaporation from the lake surface has been about equal to the precipitation on lake surface and run-off from the tributary watershed.

94. The mean monthly stage on Lake Erie has ranged from 573.24, in June, to 572.03, in February, a fluctuation of 1.21 feet. The storage on Erie has had a positive value from February to June, inclusive, and a negative value from July to January, inclusive. The mean monthly storage has had a maximum value of + 44100 cubic feet per second, in April, and a minimum value of — 31100 cubic feet per second, in September. The outflow has fluctuated between 225700 cubic feet per second, in July, and 198100 cubic feet per second, in February. The mean monthly total supply has had a maximum value of + 255700 cubic feet per second, in April, while it has fallen to a minimum value of +179200 cubic feet per second, in October. The mean monthly local supply on Erie has had a positive value from January to June, inclusive, and a negative value from July to December, inclusive. During these last six months, July to December, inclusive, the evaporation on the surface of Lake Erie has been greater than the precipitation on the lake surface and run-off from the tributary watershed. The maximum mean monthly local supply of + 56100 cubic feet per second occurred in April, while the minimum of — 31800 cubic feet per second occurred in October.

95. The mean monthly stage of Lake Ontario has ranged from 246.95, in June, to 245.57, in December, a fluctuation of 1.38 feet. The storage has shown a positive value from January to June, inclusive, and a negative value from July to December, inclusive. The mean monthly storage has had a maximum value of + 34800 cubic feet per second, in April, and a minimum value of — 28700 cubic feet per second, in September. The mean monthly outflow through the St. Lawrence River has fluctuated between 283600 cubic feet per second, in July, and 219300 cubic feet per second, in February. The mean monthly total supply has had a maximum value of + 297500 cubic feet per second, in May, and a minimum value of + 225500 cubic feet per second, in January. The mean monthly local supply to Ontario has ranged from + 83800

cubic feet per second, in April, to +18000 cubic feet per second, in September.

96. The maximum mean monthly stage of each lake of the Great Lakes has occurred at different times in the different lakes. This has been equally true with respect to the minimum stage. The maximum discharge of any lake does not occur at the time of the maximum total supply. The minimum discharge of any lake does not occur at the time of the minimum total supply. The maximum local supply of any lake does not occur at the same time as the maximum total supply; neither does the minimum local supply of any lake occur at the same time as the minimum total supply.

97. Table 30 shows the ratios, $R_{MAX.}$, between the maximum value of mean monthly discharge and the maximum value of mean monthly total supply for each lake in the system; the time interval in days, $T_{MAX.}$, which elapsed between the date of the occurrence of the maximum value of mean monthly total supply to any lake and that of the maximum value of mean monthly discharge from that lake; and the time interval, in days, $T_{MIN.}$, which elapsed between the date of the occurrence of the minimum value of mean monthly total supply to any lake and that of the minimum value of mean monthly discharge from that lake.

TABLE 30.

RATIOS—$R_{MAX.}$, $T_{MAX.}$, and $T_{MIN.}$

LAKE.	$R_{MAX.}$	$T_{MAX.}$	$T_{MIN.}$
Superior	0.524	98 days	91 days
Michigan-Huron	0.647	82 days	101 days
Erie	0.884	76 days	132 days
Ontario	0.955	56 days	20 days

98. The ratio, $R_{MAX.}$, increases with each succeeding lake in the Great Lakes system. The maximum mean monthly outflow from Superior has been about 52 per cent. of the maximum mean monthly total supply to that lake, while the maximum mean monthly outflow from Ontario has been about 96 per cent. of the maximum mean monthly total supply to that lake.

99. In order that a comparison of the several supply factors of the several lakes can be intelligently made, part of the data given in Table 28 has been expressed in cubic feet per second per square mile of watershed. Table 31 gives the mean

monthly values of storage, outflow, and total supply of Lakes Superior, Michigan-Huron, Erie, and Ontario in terms of the total watershed area, including lake surface, above the lake's outlet, and of local supply of the same lakes in terms of the tributary local watershed area including lake surface. An inspection of this table shows that the mean monthly outflow from these several lakes of the Great Lakes system has been remarkably uniform. The maximum value for Superior has been 1.22 cubic feet per second per square mile, while the minimum value has been 0.89 cubic foot per second per square mile. The maximum value for Michigan-Huron has been 1.00 cubic foot per second per square mile, while the minimum value has been 0.80 cubic foot per second per square mile. The maximum value for Erie has been 0.89 cubic foot per second per square mile, while the minimum value has been 0.78 cubic foot per second per square mile. The maximum value for Ontario has been 0.99 cubic feet per second per square mile, while the minimum value has been 0.76 cubic foot per second per square mile.

100. The mean monthly total supply to Superior has fluctuated between 2.31 cubic feet per second per square mile and —0.14 cubic foot per second per square mile. That to Michigan-Huron has fluctuated between 1.53 cubic feet per second per square mile and 0.44 cubic foot per second per square mile. That to Erie has fluctuated between 1.00 cubic foot per second per square mile and 0.70 cubic foot per second per square mile. That to Ontario has fluctuated between 1.03 cubic feet per second per square mile and 0.78 cubic foot per second per square mile.

101. The mean monthly local supply to Superior has fluctuated between 2.31 cubic feet per second per square mile and —0.14 cubic foot per second per square mile. That to Michigan-Huron has fluctuated between 1.79 cubic feet per second per square mile and 0.06 cubic foot per second per square mile. That to Erie has fluctuated between +1.62 cubic feet per second per square mile and —0.92 cubic foot per second per square mile. That to Ontario has fluctuated between +1.62 cubic feet per second per square mile and 0.55 cubic foot per second per square mile. The average local supply to Erie is considerably less than that to the other lakes. This is explained in part by the southerly position of the lake in the chain, the general direction of its principal axis coinciding with the direction of the prevailing winds, its shallow depth, and errors in winter discharge values of Detroit River,—all of which tend to decrease the local supply factor.

102. A comparison of the total supply values with the outflow or discharge values, expressed in cubic feet per second per square mile, shows the regulating effect of reservoirs on stream flow. Without reservoirs, the run-off from the lake's watershed is discharged immediately, while, with reservoirs, the run-off is stored and discharged at an approximate uniform rate.

THE REGULATION OF LAKE ERIE AS PROPOSED BY THE UNITED STATES BOARD OF ENGINEERS ON DEEP WATERWAYS.

103. The United States Board of Engineers on Deep Waterways, in 1900, reported on the regulation of Lake Erie, in appendix 6 of their report. The scheme, as proposed by them, consisted of a submerged weir, with regulating sluices, at the outlet of Lake Erie near the angle in the Bird Island Pier, by which the level of the lake might be held at or near some fixed stage. The report says:

"The regulation of the level of the lake implies the maintenance of its surface at or near some fixed stage, to accomplish which the discharge must be so controlled that it will be at all times approximately equal to the difference between the supply of water to the lake and evaporation from the lake surface."

And further, in relation particularly to Lake Erie, the report states:

"To regulate the level of Lake Erie so as to maintain its surface near some fixed place of reference will require such control of the outflow through Niagara River that the storage which would naturally occur in the lake will be discharged during the first half of the year and the outflow will be diminished a like amount during the last half of the year. This modification of outflow will not materially change the total volume of discharge for any entire year and will amount to only one-fifth of the variation of discharge of the river for different years under present conditions. The effect of this modification of flow through Niagara River, on the level of Lake Ontario, will be to slightly increase the rate of rise in the spring and make the date of maximum stage a little earlier."

104. The scheme of regulation, as proposed by the Board of Engineers on Deep Waterways, is to not allow the monthly mean stage of Lake Erie, at Buffalo, to rise above 574.5 feet, old levels, or 574.7 feet, 1903 levels, above mean tide at New York. The minimum monthly stage of lake surface, under regulation, is not definitely stated, but it is intimated to be about 573.7 feet, 1903 levels, in the following paragraphs taken from their report:

(1) "The three months in which the supply was materially in excess of the discharge for proposed regulated stage were February, March, and April, during which the excess averaged 19000 cubic feet per second, corresponding to a rise of 0.2 foot in February, 0.2 foot in March, and 0.15 foot in April. Hence, if the level of the lake, when regulated, should be allowed to fall 0.6 foot every year after the close of navigation, it is probable that the excess of supply over discharge would never cause the surface to rise above the plane of regulation."

(2) "In the fall of 1875, the discharge of Niagara River was 60000 cubic feet per second less than the capacity of the regulating works; and, if the lake had been regulated, with the sluices of the regulating works all open, the surface would have been lowered one foot in about two months, or sufficient to have stored the excessive supply which occurred in the spring of 1876, with a margin of 0.4 foot for contingencies."

105. According to the discharge equation determined by the Board of Engineers on Deep Waterways, the maximum discharge of Niagara River was 277270 cubic feet per second, with the lake regulated at stage 574.70, 1903 levels, and the minimum discharge was 178000 cubic feet per second at stage 570.70, 1903 levels. The discharge formula of Niagara River, deduced by the International Waterways Commission, is based upon more complete data and gives the maximum discharge as 261500 cubic feet per second at 574.7, 1903 levels, and the minimum as 166700 cubic feet per second at stage 570.7, 1903 levels. In this report, the latter discharge values are used instead of those of the Board of Engineers on Deep Waterways.

PRACTICAL REGULATION OF LAKE ERIE BETWEEN STAGES 573.7 AND 574.7, 1903 LEVELS.

106. In working out a practical scheme for regulation, it is quite necessary to set a definite elevation for the regulated stage of Lake Erie at the beginning of each month. The stage values used in this investigation are given in Table 32.

TABLE 32.

STAGE OF LAKE ERIE DESIRED ON FIRST OF MONTH, WITH REGULATED CONDITIONS.

MONTH.	Stage Desired at Beginning of each Month.	MONTH.	Stage Desired at Beginning of each Month.
January 1,	573.8	August 1,	574.0
February 1,	573.7	September 1,	574.0
March 1,	573.7	October 1,	574.0
April 1,	573.8	November 1,	574.0
May 1,	573.9	December 1,	573.9
June 1,	574.0	January 1,	573.8
July 1,	574.0		

107. The maximum desired stage of water from June 1st to November 1st, inclusive, as shown in the above table, allows 0.7 foot for contingencies, which, as will be seen, is not adequate. The regulation of the elevation of the level of Lake Erie between stages 573.7 and 574.7 is a difficult proposition on account of the variation in total supply. It is impossible

to estimate this factor with any degree of accuracy on account of the fluctuation of inflow, precipitation, run-off, and evaporation. This fact is very strongly brought out in the data and results shown in Table 33 and Plate 19, "Regulation of Lake Erie between stages 573.7 and 574.7." The difference between the expected total supply and the actual total supply for any one month has been as great as +47800 cubic feet per second, in April, 1891, and —40200 cubic feet per second, in April, 1892, which would have caused a difference in the expected change in stage of Lake Erie of 0.4 to 0.5 foot. In June, 1892, (see Table 33) the lake level is supposed to have reached 574.0 on the 1st of July, and regulating works are assumed to have been set to give a discharge that would bring the lake to this stage by the first of the following month, but, owing to the increase in the actual total supply over the expected total supply, the lake would have risen to 574.64, which is 0.64 foot more than the desired and estimated stage. This unlooked-for variation in a high-water year, such as 1876, might prove disastrous if the lake level were at or near stage 574.7. By examining Table 33, it is also seen that the regulated level of Lake Erie would have fallen, in most years, during some of the winter months, to 573.3, approximately, or 0.4 foot below the minimum stage set by the Board of Engineers on Deep Waterways, but would have risen above 573.7 by the opening of the season of navigation. With the proposed scheme of regulation, for the period from 1890 to 1906, inclusive, the level of Lake Erie would have risen 0.04 foot above 574.7, in June, 1892.

108. The period from 1890 to 1906, inclusive, does not include an extreme high-water year. If the proposed scheme of regulation had occurred in 1876, when the monthly mean stage of Lake Erie reached 574.5, in June, then the assumed maximum level (574.7) would have been exceeded, during April to July, inclusive, by 0.03, 0.19, 0.20, and 0.05 foot, respectively, (see Table 33).

109. During the period from 1890 to 1906, inclusive, with regulation, the mean level of Lake Erie would have been raised from 572.1 to about 573.9, an increase in mean stage of 1.8 feet. During the low-water year of 1895, the mean annual level, with regulation, would have been 2.57 feet higher than the actual stage. The extreme low monthly mean stage of 570.71, in November, 1895, would have been raised by regulation to 573.59, an increase of 2.88 feet. The actual oscillation in monthly mean water level of Lake Erie has been about 3.89 feet. With regulation as proposed, the range of monthly

mean oscillation would have been reduced to 1.43 feet during the year, and to 1.14 feet during the navigation season.

110. Perfect regulation is impossible. The monthly increase in stage of Lake Erie, with natural conditions, is frequently 0.4 to 0.5 foot; occassionally exceeds 0.8 foot; and has been as great as 0.98 foot. Daily oscillations in the stage are occasionally as large as 7 or 8 feet, and hourly variations sometimes exceed 2 feet. Southwesterly storms on the lake raise the water level at Buffalo and lower it at Amherstburg by several feet from the normal. This difference of level has been as large as 15 feet with the severest storms. To control this daily and hourly variation in stage of Lake Erie within small limits is impossible.

EFFECT OF REGULATION OF LAKE ERIE, BETWEEN STAGES 573.7 AND 574.7, ON WATER LEVELS OF LAKE ONTARIO AND ST. LAWRENCE CANALS.

111. The effect of the regulation of the stage of Lake Erie, between 573.7 and 574.7, on the water levels of Lake Ontario, for the period from 1890 to 1906, inclusive, is shown on Plate 20, which illustrates the increased range in stage of Lake Ontario and the detrimental effect to navigation in the St. Lawrence canals due to the proposed regulation of Lake Erie under the scheme proposed by the Board of Engineers on Deep Waterways.

PRACTICAL REGULATION OF LAKE ERIE BETWEEN STAGES 572.0 AND 574.5, 1903 LEVELS.

112. Inasmuch as it is deemed impracticable to regulate the monthly mean stage of Lake Erie between stages 573.7 and 574.7 feet above mean tide at New York, as proposed in the plan of the Board of Engineers on Deep Waterways, the investigation was continued to determine the limits between which the regulation of the monthly mean stage of Lake Erie would be practicable.

113. As in the previous plan of lake regulation, a definite elevation for the stage of the lake on the first of each month has been assumed. These values represent the limits within which it would be necessary to attempt to hold the stage of Lake Erie so that the maximum and minimum monthly mean water levels of 574.5 and 572.0, respectively, would not be exceeded. Table 34 shows the assumed elevations desired on the first of month, of the water surface of Lake Erie, for regulation of its monthly mean stage between 572.0 and 574.5.

TABLE 34.

STAGE OF LAKE ERIE DESIRED ON FIRST OF MONTH WITH LAKE REGULATED BETWEEN 572.0 AND 574.5.

MONTH.	Stage Desired at Beginning of each Month.	MONTH.	Stage Desired at Beginning of each Month.
January 1,	572.3	August 1,	572.5
February 1,	572.2	September 1,	572.5
March 1,	572.2	October 1,	572.5
April 1,	572.2	November 1,	572.5
May 1,	572.3	December 1,	572.4
June 1,	572.4	January 1,	572.3
July 1,	572.5		

114. An inspection of Table 34 shows that 2.0 feet and 0.2 foot have been allowed for the actual fluctuations from the desired maximum and minimum monthly mean stages, respectively, of Lake Erie, with regulation. This extreme allowable fluctuation from the desired maximum is necessitated by the extreme high water of 1876, during which year the surface of Lake Erie, at Buffalo, reached a mean level of 574.49, in June, or but 0.01 foot less than the maximum monthly mean stage allowable with regulation.

115. As 1876 is the controlling high-water year, so 1895 is the controlling low-water year. Computations have been made for these two extreme years instead of for the period from 1890 to 1906, inclusive, as in the investigation of the scheme outlined by the Board of Engineers on Deep Waterways.

116. Table 35 and Plate 21 show that, with regulation, the water levels of Lake Erie, at Buffalo, differ but slightly from the actual levels for the year 1876, while for the low-water year of 1895 the annual mean level would be increased from 571.26 to 572.33, a change of + 1.07 feet, and the mean level for the extreme low-water months of November and December (both in the navigation season) would be increased from 570.71 and 570.97 to 572.09 and 572.34, respectively, or a change of + 1.38 feet and + 1.37 feet, respectively.

EFFECT OF REGULATION OF LAKE ERIE, BETWEEN STAGES 572.0 AND 574.5, ON WATER LEVELS OF LAKE ONTARIO AND ST. LAWRENCE CANALS.

117. Any change in the outflow of Lake Erie will change the water levels of Lake Ontario. If the inflow to Ontario is increased, the lake level will rise, and with decreased inflow the

level will fall. Table 36 and Plate 21 show the effect on the water levels of Lake Ontario for the years of 1876 and 1895, if Lake Erie stage had been regulated between stages 572.0 and 574.5 for those years. The effect of the regulation of Lake Erie would have been to increase the fluctuation in stage of Lake Ontario, causing higher stage in spring and lower stage in the autumn than under actual conditions.

118. For the high-water year of 1876, during which time the regulated inflow would have differed but slightly from the actual, there would have been no appreciable increase in the fluctuation in stage on Lake Ontario, and at no time during the year would the regulated stage differ from the actual by more than 0.12 foot. In 1895, however, a low-water year on Lake Ontario as well as on Lake Erie, the fluctuation would have increased with the result that during the months from September to December, inclusive, the regulated stages would have fallen to 243.70, 243.26, 243.08, and 243.33, respectively, or 0.34, 0.38, 0.33, and 0.18 foot, respectively, below the actual stages for those months.

119. During an extended period, such as from 1890 to 1906, inclusive, differences of 0.4 to 0.5 foot between the actual stage of Lake Ontario and the stage that would have prevailed under regulated conditions on Lake Erie would be of frequent occurrence. Unfortunately, these variations, with respect to actual stage, are generally negative during the period of low water and positive during the period of high water. Such conditions, caused by regulating Lake Erie, would injuriously affect navigation in the St. Lawrence canals and would decrease the draft of vessels by 0.4 to 0.5 foot, in the Galop canals, and 0.7 to 0.8 foot, in the Morrisburg canals. Barges and tows that now load to 14 feet draft would be compelled to load to not more than 13.2 or 13.3 feet draft during September, October, and November, in most years, and in some years, during the entire season of navigation.

EFFECT OF REGULATION OF LAKE ERIE, BETWEEN STAGES 572.0 AND 574.5, ON WATER LEVELS OF NIAGARA RIVER.

120. By the proposed system of regulation, the stage of water in the Niagara River would not fluctuate through any greater range than under actual conditions. During the winter months, more frequent low water would probably occur under regulation than under actual conditions, in which case the power companies at Niagara Falls would probably have more difficulty in keeping the channels to their intakes free

from ice. During the fall months, navigation in the river might be slightly interfered with owing to the storage in the lake of a part of the natural discharge.

EFFECT OF REGULATION OF LAKE ERIE, BETWEEN STAGES 572.0 AND 574.5, ON WATER LEVELS OF LAKE ST. CLAIR, LAKE MICHIGAN-HURON AND CONNECTING WATERS.

121. By the proposed regulation of Lake Erie between stages 572.0 and 574.5, the mean level of this lake would have been raised about 1 foot. This increase in stage would have decreased the mean slope in the Detroit River and would have caused Lake St. Clair to rise until the discharge through the Detroit River had a value equal to the discharge under natural conditions for the same period. An examination of Tables 8 and 9 shows that the mean stage of Lake St. Clair, at Windmill Point, was 575.40, and that of the lower end of the Detroit River, at Amherstburg, was 572.84. From equation 30, the discharge of the Detroit River is computed to be 204900 cubic feet per second for mean stages of 575.40, at Windmill Point, and 572.84, at Amherstburg. For this river-discharge value and with the stage at Amherstburg increased by 1.0 foot, the amount that mean level of Lake Erie would have been raised by regulation, it is found that the stage of Lake St. Clair, at Windmill Point, would eventually rise 0.61 foot. This value represents the effect on the stage of Lake St. Clair due to the increase of 1.0 foot in mean stage of Lake Erie under regulation.

122. The rise between actual and regulated low-water stage of Lake Erie would be greater than the corresponding rise between actual and regulated high-water stage. The effect of this would be to slightly lessen the discharge of the Detroit River at low stage and to slightly increase it at high stage.

123. As backwater from Lake Erie raises the water level of Lake St. Clair, so backwater from Lake St. Clair raises the water level of Lake Michigan-Huron. For a given flow in the Detroit River, an increase in the stage of Lake Erie causes an increase in the stage of Lake St. Clair; likewise, for a given flow in the St. Clair River, an increase in the stage of Lake St. Clair causes an increase in the stage of Lake Michigan-Huron. By the method used above, the effect on the water level of Lake Michigan-Huron, caused by 0.61 foot backwater on Lake St. Clair, due to the regulation of Lake Erie, has been computed to be 0.27 foot rise.

124. A study of Plate 21 shows that for a year of excessive, or above-normal supply, such as 1876, the regulation of Lake Erie would not materially improve navigation. In 1895, a year of deficient supply, the mean level during the eight-month season of navigation would have been increased from 571.31 feet, under natural conditions, to 572.41, under regulated conditions, and navigation on Erie would have been improved by an increased stage of 1.1 feet. The regulation of Lake Erie, between stages 572.0 and 574.5, would raise extreme low stage for the navigation season by at least 1 foot, without an appreciable increase in the extreme high stage. This increase in low stage is equivalent to deepening every harbor and channel in Lake Erie by that amount; in the Detroit River and Lake St. Clair, by at least 0.61 foot; and in the St. Clair River and Lake Michigan-Huron by at least 0.27 foot.

REGULATION OF LAKE SUPERIOR.

125. The regulation of the stage of Lake Superior has been suggested as a means (first) for improving navigation on that lake, and (second) to compensate for the diversion of water from Lake Michigan-Huron through the Chicago Drainage Canal.

126. This Commission has already recommended in its report upon the conditions existing at Sault Ste. Marie that "the level of St. Marys River, above the rapids, shall be maintained between the elevations 601.7 and 603.2 above mean tide at New York." The monthly mean stage of St. Marys River, above the rapids, has not risen above 603.2 since 1860, except in September and October, 1869, and July, August, and September, 1876. It has fallen below 601.7 on numerous occasions, generally during the winter months. In 1879 and 1891, the monthly mean stage did not exceed 601.5, while in 1892 it exceeded 601.7 in only one month. The fall in the water level of the St. Marys River above the rapids, below 601.7, for the ice months of January to April, inclusive, does not interfere with navigation on Lake Superior. The monthly mean water level of Lake Superior was below 601.7 about 20 per cent. of the navigation season (May to December, inclusive), from 1860 to 1888, inclusive. For this cycle of years, the regimen of the St. Marys River had not been materially altered by artificial works. With the completion of the International Bridge piers and approaches in 1888, and the shutting off of spans 1 and 2 of this bridge from the rapids by the Chandler-Dunbar Water Power Company, in 1892, these two principal obstructions to the natural outflow from Lake Superior have

raised the water level so that it has not fallen below 601.7 more than about 2 per cent. of the navigation season from 1893 to 1907, inclusive. The difference cannot be attributed to the variation in the total supply, or water-yield, to Lake Superior; for, as a matter of fact, the average total supply for the period from 1860 to 1888, inclusive, was about 4400 cubic feet per second greater than for the period from 1893 to 1907, inclusive.

127. The construction of the compensating works at the head of the St. Mary's Rapids by the Michigan Lake Superior Power Company, in 1901 and 1902, cut off a flow of about 9900 cubic feet per second. The 8500 cubic feet per second of water used by this company since 1905 nearly neutralizes the effect of these works.

128. The regulation of Lake Superior during the navigation season, between the elevations 601.7 and 603.2, as measured by the level of the St. Marys River above the rapids, has been accomplished under the conditions that did exist, and no further works seem to be necessary until a change in the artificial diversions at Sault Ste. Marie is made.

129. If the monthly mean level of Lake Superior were to be controlled during the navigation season within a smaller fluctuation than 1.5 feet, then the outflow through the St. Marys River would have to be artificially controlled. In order to eliminate the monthly mean fluctuation in large natural reservoirs, such as Lake Superior and the other lakes in this system, it would be necessary to increase the fluctuations of outflow to correspond to the fluctuations of total supply to that reservoir. To accomplish this result on Lake Superior, the monthly mean outflow would have had a maximum value of 333300 cubic feet per second, in August, 1869, and a minimum value of —106600 cubic feet per second, in December, 1870. Such fluctuations in outflow are impossible, since the minimum discharge of any stream is zero. When the total supply is minus, the level of the lake or reservoir will fall even if the outflow is entirely shut off.

130. The question that now presents itself, since perfect regulation of Superior is impossible, is: Can the fluctuations in stage of Lake Superior be materially reduced; and if so, what would be the effect on the lower lakes. An examination of Table 24 shows that during November and December, 1870, and January, 1871, the total monthly supply to Lake Superior for these three consecutive months was —99500, —106600, and —42900 cubic feet per second, respectively, equivalent, collectively, to a total depth on the lake surface of —0.732 foot.

The level of Lake Superior actually fell 1.41 feet during this period, but, even if the outflow through the St. Marys River had been entirely shut off, the lake would still have fallen over eight and three-quarters inches. During May, June, and July, in the high-water year of 1876, the total monthly supply to Lake Superior was 303300, 291200, and 205000 cubic feet per second, respectively,—a total of 799500 cubic feet per second, equivalent to a depth on lake surface of +2.351 feet. The outflow through the St. Marys River for the corresponding period was 95800, 109200, and 120000 cubic feet per second, respectively, or an average monthly flow of 108300 cubic feet per second. Granting that this enormous supply of water could have been predicted,—an impossibility—and that the St. Marys River could have discharged twice the average monthly outflow, or 216600 cubic feet per second, for three months, through artificial works and channels, which would be very costly to construct, Lake Superior would still have risen over 5¼ inches.

131. If the monthly oscillations in stage of Lake Superior could be materially reduced, then the monthly mean flow through the St. Marys River would fluctuate more than it actually does. Under present conditions, the outflow through the St. Marys River is the greatest during August, September, and October, when the stage of Lake Michigan-Huron is falling very rapidly. Under these natural conditions, the water from Lake Superior aids in the attempt of nature to hold the stage of Lake Michigan-Huron at a fixed elevation. If the outflow from Lake Superior in an average year were increased as much as 50 per cent. during August, September, and October, the level of Lake Michigan-Huron would be raised only about 0.1 foot per month for these months, since the discharge through the St. Marys River is not the supply factor that produces the principal effect on the stage of Lake Michigan-Huron.

132. These cases show, first that the artificial regulation of Lake Superior would not materially decrease the present fluctuation of water level; second, that Lake Superior is one of the best naturally regulated bodies of water in the world; and third, that the effect of the artificial regulation of the level of Lake Superior on the level of Lake Michigan-Huron would produce only insignificant results.

DIVERSION OF WATER THROUGH CHICAGO DRAINAGE CANAL, THE EFFECT OF DIVERSION ON LAKES MICHIGAN-HURON, ERIE, AND ONTARIO, AND THE REGULATION OF LAKE SUPERIOR TO COMPENSATE FOR DIVERSION AT CHICAGO.

133. The Chicago Drainage Canal has diverted water from Lake Michigan-Huron since 1900. This has lowered the level of Lakes Michigan-Huron, St. Clair, Erie, and Ontario, regardless of the fact that these lakes are at higher stages than they were when the canal was opened. These higher stages are due to the increase in the quantity of water supplied since 1900. If this supply had not been increased, then the stages of the lakes would have been actually less. Plates 22, 23, and 24 show the monthly loss of level on Lakes Michigan-Huron, Erie, and Ontario, respectively, under the actual diversion through the Chicago Drainage Canal, and also under assumed diversions of 10000 and 14000 cubic feet per second.

TABLE 37.

LOSS OF LEVEL ON LAKES MICHIGAN-HURON, ERIE, AND ONTARIO UNDER THE ACTUAL DIVERSION AND UNDER ASSUMED DIVERSIONS OF 10000 AND 14000 C. F. S. THROUGH THE CHICAGO DRAINAGE CANAL, 1900-1907, INCLUSIVE.

LAKE.	LOSS OF LEVEL IN INCHES.		
	Actual Diversion.	Assumed Diversion of	
		10000 c. f. s.	14000 c. f. s.
Michigan-Huron	2-5/8	6-1/2	9-3/8
Erie	2-1/2	5-7/8	8
Ontario	1-7/8	4-1/4	6

134. The stage of Lake Michigan-Huron is 2⅝ inches lower than it would have been if there had not been any water diverted through the Chicago Drainage Canal. Likewise, the stages of Lake Erie and Lake Ontario are 2½ and 1⅞ inches lower, respectively, than they would have been with no diversion at Chicago. If the quantity of water diverted through the canal had been as much as 10000 or 14000 cubic feet per second, then the effect would have been proportionately greater.

135. Since the effect of the diversion is to lower the level of the lakes and connecting channels of the Great Lakes system, with the exception of Lake Superior and the upper St. Marys River, and as this effect will increase with the increase in the quantity of water diverted, therefore, the ques-

tion presents itself: Can the present diversion or future diversions through the Chicago Drainage Canal be compensated for by the use of Lake Superior as a storage reservoir, so that the level of the lakes below Superior will not be lowered?

136. The longest low-stage period of outflow from Lake Superior has been selected in order to obtain a solution to the question. An examination of Plates 2 to 5, inclusive, shows that such a period occurred between June, 1888, and August, 1893. The average flow for the low-water year of 1892 was 65700 cubic feet per second. Assuming a continuous discharge from Superior of the average flow for that year, and, in addition, first, 4000 and, second, 14000 cubic feet per second, respectively, to compensate for a diversion of these amounts through the Chicago Drainage Canal, or a total continuous discharge of, first, 69700 cubic feet per second, and, second, 79700 cubic feet per second, respectively, between June 1, 1888, and August 31, 1893, then the regulated stages of all the lakes in the Great Lakes system would have differed materially from the actual stages. Plate 25 and Tables 38, 39, 40, 41, and 42 show these changes in stage of Lakes Superior, Michigan-Huron, Erie, and Ontario, due to regulation of outflow from Lake Superior to compensate for diversions through the Chicago Drainage Canal of 4000 and 14000 cubic feet per second.

137. To compensate for a diversion of 4000 cubic feet per second through the Chicago Drainage Canal, with the continuous discharge of water from Lake Superior of 69700 cubic feet per second between June 1, 1888, and August 31, 1893, the stage of the St. Marys River, as measured at Sault Ste. Marie, (above the locks) would have been higher than it was actually. In August, 1893, the level of Superior would have returned to approximately the actual stage. Under assumed conditions, the mean stage of Lake Superior would have been increased during the period from June, 1888, to August, 1893, at the expense of the decrease in stage of Lakes Michigan-Huron, Erie, and Ontario. The cumulative effect of the constant discharge of 69700 cubic feet per second from Lake Superior during this five-year period would have been to lower the monthly mean stage of Lake Michigan-Huron from 579.88 to 579.53, and from 579.82 to 579.48, in November and December, 1891, respectively. These stages would have been only 0.36 and 0.48 foot higher, respectively, than the actual stages for the corresponding months of November and December in the extreme low-water year of 1895, and would have

been 0.23 and 0.28 foot lower, respectively, than the mean stage for the entire navigation season of 1895, when the shipping interests were so seriously affected. This constant discharge of water from Lake Superior would also have lowered the monthly mean stage of Lake Erie from 571.21 to 570.89, and from 571.28 to 570.96, in November and December, 1891, respectively, which would have been only 0.19 and 0.19 foot higher, respectively, than the actual stages in November and December, 1895. The monthly mean stage of Lake Ontario would have been decreased by this discharge from Lake Superior from 244.44 to 244.19, and from 244.41 to 244.16, in November and December, 1891, respectively.

138. At the end of August, 1893, the water stored in Lake Superior would have been delivered to the lower lakes, and no storage water would have been available, in addition to the actual supply, to compensate for the diversion of water through the Chicago Drainage Canal, and prevent the mean levels of Lakes Michigan-Huron, Erie, and Ontario falling below the actual stages.

139. The monthly mean discharge of the St. Marys River was greater than 69700 cubic feet per second in September, October, and November, 1893. This excess would have allowed 6900, 5800, and 4800 cubic feet per second of water, respectively, to have been stored in Lake Superior in these months. The storage of this volume of water would have temporarily taken it away from the supply to Lake Michigan-Huron, and would have lowered the level of that lake temporarily. Later, when this stored water would have been discharged into the lakes below, their stages would have been the same as under natural conditions, and during the interval between the storage and discharge of this water the diversion of water through the Chicago Drainage Canal would have lowered the mean level of Lakes Michigan-Huron, Erie, and Ontario as it has under actual conditions. If the outlet were to have been artificially changed so that the St. Marys River could have discharged 4000 cubic feet per second in addition to the actual discharge, beginning with September, 1893, in order to compensate for an assumed diversion of this amount at Chicago, then it would have been only a few years before Lake Superior would have fallen so low in stage that navigation would have been seriously interfered with.

140. To compensate for a diversion of 14000 cubic feet per second through the Chicago Drainage Canal, with the continuous discharge of water from Lake Superior of 79700 cubic feet per second between June 1, 1888, and August 31, 1893,

the stage of the St. Marys River, as measured at Sault Ste. Marie, (above the locks) would have been lower by 1.4 feet than it was actually. This increased discharge from Lake Superior would produce the same effect on the lower lakes as the effect of the previous discharge of 69700 cubic feet per second, since the increased outflow from Lake Superior would be taken by the additional diversion through the Chicago Drainage Canal. The stage of the St. Marys River, at Sault Ste. Marie, (above the locks) would have fallen, in May, 1893, to slightly below 600.0, which would have seriously interfered with the navigation of Lake Superior by the present lake vessels. At the end of this five-year period, the level of Lake Superior would have been extremely low and water would not have been available for storage in Lake Superior for the next low-water period.

141. The annual mean stage of the St. Marys River, above the locks, fell to 600.96, in 1879. This minimum value must not be taken as a criterion for permissible low water for navigation purposes; neither should it be assumed that the minimum annual mean stage on the remaining lakes, as a permanent level, would be satisfactory to navigation.

142. The artificial storage of water in Lake Superior must be commenced by shutting off the transmitted supply to the lakes below Superior in the Great Lakes system. When the stored water is allowed to flow from Lake Superior, the total supply to Lakes Michigan-Huron, Erie, and Ontario will be the same as under actual conditions, and the mean level of these lakes will remain unchanged.

143. An artificial storage of water in Lake Superior has taken place, beginning with the construction of the International Bridge and its approaches in 1888. The storing of this water in Superior has withheld it temporarily from the lakes below, and, as a result, the stages of the latter have been changed from what they would have been if there had been no artificial changes in the outlet to Lake Superior. Plates 26, 27, 28, and 29 show the monthly mean stages of the Great Lakes under actual conditions and as they would have been if no artificial works had been built in the upper St. Marys River.

144. An inspection of Plate 26 shows that the artificial storage of water in Lake Superior, created by the building in the upper St. Marys River of the International Bridge and approaches in 1888, of cutting off from the rapids the flow through spans 1 and 2 of this bridge from the American shore by the Chandler-Dunbar Water Power Company in 1892, and

of building the compensating works immediately above the bridge, on the Canadian side, by the Michigan Lake Superior Power Company in 1901, has raised the monthly mean level of Lake Superior approximately 1 foot (0.966) in August, 1904. Owing to diversions of water at Sault Ste. Marie for power and other purposes, this effect is less by about 0.4 foot than the computed ultimate rise due to these obstructions. Since January, 1905, when the Michigan Lake Superior Power Company began to divert approximately 8500 cubic feet per second of water from the river for power purposes, the difference between the actual and original efflux stages has decreased to approximately 0.6 foot, a loss in level between 1904 and 1907 of 0.4 foot. Under original efflux conditions, the monthly mean level of Lake Superior would have fallen from 601.02 to 600.76, in April, 1892; from 601.01 to 600.82, in February, 1893; from 601.46, to 600.92, in March, 1898, and from 601.88 to 601.02, in March, 1903. The annual mean stage of Lake Superior, for 1904, would have been 601.84 under original conditions, while it was 602.71 under actual conditions. This artificial storage of water, due to the obstructions at the controlling section of the upper St. Marys River, partly explains why the stage of Lake Superior has been gradually rising while the stages of the lower lakes have not followed the same general upward trend.

145. The storing of water in Lake Superior has had its effect on the stage of the lower lakes. An increase in the transmitted supply from Lake Superior raises the stage of Lake Michigan-Huron an amount equal to the increase divided by the increment of discharge through the St. Clair River. The amount of additional water from Lake Superior that would have flowed into Lake Michigan-Huron between December, 1888, and December, 1904, is equivalent to the decrease in storage on Superior. This quantity represents a slice 0.87 foot thick over the entire surface of Lake Superior, equivalent to an average monthly increase in discharge of 1530 cubic feet per second through the St. Marys River between December, 1888, and December, 1904, inclusive. Under actual conditions this increase in discharge would not be a constant quantity but would change according to the effect of the obstruction or the diversion. Plate 27 shows a comparison of the monthly mean water levels of Lake Michigan-Huron under actual and original efflux conditions of the St. Marys River. The effect of storing water in Lake Superior by cutting off of spans 1 and 2 of the International Bridge at Sault Ste. Marie, in 1892, by the Chandler-Dunbar Water Power Company, was to lower

Lake Michigan-Huron by about 0.15 foot in 1894 and 1895. In 1896, the Lake Superior Power Company began to use water for power purposes on a large scale, which partially counteracted the effect of the obstructions. In 1902, the effect of the compensating works of the Michigan Lake Superior Power Company was to lower Lake Michigan-Huron by about 0.15 foot. In 1905 the Michigan Lake Superior Power Company began the diversion of water through their canal on the American side, which has, apparently, raised the stage of Lake Michigan-Huron about 0.1 foot, but in so doing it has been done at the expense of lowering Lake Superior by about 0.4 foot.

146. The effect on Lakes Erie and Ontario of the artificial storage of water in Lake Superior is slightly less than the effect on Lake Michigan-Huron. This decrease in effect is due to the increase in the increment of discharge of the outlets of Lakes Erie and Ontario. Plates 28 and 29 show a comparison of the monthly mean water levels of Lake Erie and of Lake Ontario, respectively, under actual and original efflux conditions of St. Marys River. While the effect of the cutting off of the flow through spans 1 and 2 from the rapids of the St. Marys River occurred about December, 1892, it was not materially felt on Lake Michigan-Huron until the latter part of 1893; not in Lake Erie until the middle of 1894, and not in Lake Ontario until the end of 1894. The effect of the construction of the compensating works at Sault Ste. Marie by the Michigan Lake Superior Power Company is also noticeable on these lakes. All the other changes in stage on Lake Michigan-Huron are faithfully reproduced on the stage of Lakes Erie and Ontario, the only difference being that they occur a little later and the effect becomes slightly less on each lake lower in the series. Where the maximum effect on Lake Michigan-Huron was about 0.15 foot, it was about 0.12 foot on Lake Erie, and about 0.10 foot on Lake Ontario.

147. The artificial storage of water in Lake Superior between December, 1888, and December, 1907, inclusive, by the placing of obstructions in the upper St. Marys River, has had the effect of raising the mean stage of Lage Superior by about 0.87 foot in 1904, and of lowering Lake Michigan-Huron, Lake Erie, and Lake Ontario by a maximum of 0.15, 0.12, and 0.10 foot, respectively. This hydraulic experiment, which has been carried on since 1888, shows that the use of Lake Superior as a storage reservoir can not be successful

if navigation is to be maintained unimpaired on Lake Superior and the St. Marys River.

REGULATION OF LAKE MICHIGAN-HURON.

148. To regulate the level of Lake Michigan-Huron near some fixed plane of reference would require regulating works at or near the head of the St. Clair River. The storage in the lake, that occurs in the first part of the year, could then be discharged through these works, while the outflow from the lake during the last half of the year could be diminished by an amount equal to the negative storage. An examination of Table 28 and Plate 18 shows that the monthly mean total supply to Lake Michigan-Huron for an average year has been as great as 237700 cubic feet per second, in May, and as small as 96200 cubic feet per second, in November. Plates 7 and 6 show that the maximum and minimum monthly mean total supply has been 470800 cubic feet per second, in June, 1883, and —32000 cubic feet per second, in September, 1871, respectively. The maximum monthly mean discharge from this lake, which occurred in July, 1883, has been determined as 275400 cubic feet per second. On the basis of the above extremes for total supply, to accomplish perfect regulation of this lake would necessitate provision for a maximum outflow of 470800 cubic feet per second, and a minimum of —32000 cubic feet per second. This required maximum outflow is 195400 cubic feet per second, or 71 per cent., greater than the actual maximum. If the outflow from Lake Michigan-Huron had been entirely shut off in September, 1871, the lake would still have fallen about 0.07 foot during that month. For the period of five months, August to December, 1871, inclusive, the average outflow from Lake Michigan-Huron, with perfect regulation, would have been only 43500 cubic feet per second; likewise, for the period of five months, August to December, 1894, inclusive, and for the months of September, October, and November, in the low-water year of 1895, the average outflow with perfect regulation would have been only 71700 and 46600 cubic feet per second, respectively. On account of the small quantity of water that would have flowed in the St. Clair and Detroit rivers during these three periods, the stage of these rivers, of Lake St. Clair and of Lake Erie would have been lowered several feet below the lowest known monthly water levels, and present navigation on the Great Lakes, below Lake Michigan-Huron, would have been entirely suspended.

149. These examples that have been cited show that the perfect regulation of Lake Michigan-Huron at a fixed plane of reference is not feasible even if it were possible to predict the quantity of water that nature would supply to any lake in any month.

150. The discharges of the St. Clair and Detroit rivers during the navigation season are comparitively uniform owing to the effect of the increased slopes in the rivers counteracting the effect of the decreased stages in the lakes. With the regulation of Lake Michigan-Huron, the discharge would be greatly increased during April, May, June, and July, and greatly decreased during August, September, October, and November. The latter are the critical months for the navigators. Any change in the flow of these two rivers, whereby the fluctuation in discharge would be increased, would prove a detriment to navigation.

151. Granting that the regulation of Lake Michigan-Huron could be accomplished by artificial works, the effect on the stage of water in the St. Clair River, Lake St. Clair and Detroit River would be so serious that any benefit derived from the increased depths in Lake Michigan-Huron would be more than offset by the decreased depths in the St. Clair River, Lake St. Clair, Detroit River, and the western end of Lake Erie.

152. At the present time, the stage of Lake Michigan-Huron is partially regulated by natural agencies. Nearly every winter, nature forms a regulating works in the St. Clair or Detroit river. These works consist of ice gorges, which retard the outflow from Lake Michigan-Huron, thereby storing water to be let out during the navigation season when it is so greatly needed in the lakes and connecting channels below Lake Michigan-Huron.

REGULATION OF LAKE ONTARIO.

153. To control the stage of Lake Ontario near some fixed level, regulating works could be constructed at the head of the Galop Rapids in the St. Lawrence River. These works would control the outflow from Lake Ontario and maintain the levels of the lake within definite limits. For perfect regulation, the storage in the lake must be discharged during the first half of the year and the outflow must be diminished by the amount of the negative storage during the last half of the year. An examination of Table 28 and Plate 18, shows that, for an average year, the monthly mean total supply to Lake Ontario has fluctuated between 297500 cubic feet per

second, in May, and 225500 cubic feet per second in January, while the monthly mean outflow has varied from 283600 cubic feet per second, in July, to 219300 cubic feet per second, in February. The maximum monthly mean total supply has been as large as 382400 cubic feet per second, in April, 1870, and as small as 154100 cubic feet per second, in February, 1875, while the maximum monthly mean discharge has been as large as 351200 cubic feet per second, in May, 1862, and as small as 152200 cubic feet per second, in February, 1902. In order to accomplish perfect regulation without enlarging the river cross section, the stage of Lake Ontario must be held at such a level that the outflow can be as great as 382400 cubic feet per second, or 31200 cubic feet per second greater than the maximum discharge to date. This required maximum outflow is only 9 per cent. greater than the actual maximum. For the low-water year of 1895, the average total supply was 185700 cubic feet per second, while the average outflow was 191600 cubic feet per second. If the oscillations in the levels of Lake Ontario are to be decreased without exceeding the extreme high water of 248.95, then the level of the lake should be held at such a stage that it will never exceed this maximum limit in months of excessive supply. Two consecutive months of excessive supply occurred in April and May of 1862, when the water-yield was 375600 and 372000 cubic feet per second, respectively. The outflow through the St. Lawrence River at regulated stage 248.95 would be about 350500 cubic feet per second. With a maximum discharge through the regulating works, there would still have been an excess in supply of 25100 and 21500 cubic feet per second, corresponding to a rise in lake surface of 0.33 foot, in April, and 0.28 foot, in May, or a total of 0.61 foot in the two months. Hence, if the level of the lake, under regulation, were allowed to fall 0.6 foot, or to 248.35, after the close of the season of navigation, then the plane of regulation of Lake Ontario would probably never be exceeded.

154. Regulating works, designed to discharge about 150000 cubic feet per second, as a minimum, and 350500 cubic feet per second, as a maximum, could be located at the head of the Galop Rapids and would control the monthly mean level of Lake Ontario between 246.95 and 248.95, a range of 2 feet. This scheme of regulation would reduce the fluctuations in lake level from 5½ feet to within 2 feet, and would raise the mean level of Lake Ontario about 2 feet.

155. The effect on the stage of water in the St. Lawrence canals with this scheme of regulation of Lake Ontario

would be to cause higher water in the first part and lower water in the last part of the navigation season. Such results would injuriously affect navigation.

COMPENSATING WORKS IN THE NIAGARA RIVER.

156. Your committee had hoped to present a discussion of a project for compensating Lake Erie for the loss of level due to diversions, by works placed above the rapids approaching Niagrara Falls. A preliminary examination, however, revealed a lack of data, which prevents consideration of the question at this time.

E. E. HASKELL,
Member, American Section.

LOUIS COSTE,
Member, Canadian Section.

ATTEST: W. EDWARD WILSON, C. E.,
Secretary, American Section.

TABLE 2.

WATER LEVELS OF LAKE SUPERIOR.

Monthly mean elevations of water surface of Lake Superior, at Superior, Wis., and Marquette, Mich., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	602.69	602.44	602.42	602.99	602.92	603.09	603.05	603.10	603.08	603.13	602.95	602.69	602.81
a 61	b 2.40	2.15	2.01	2.42	3.05	3.20	3.36	3.32	3.23	3.26	3.02	2.84	2.89
a 62	2.19	2.00	2.03	2.09	2.77	2.76	2.73	2.90	3.02	2.93	2.62	2.25	2.49
a 63	2.16	2.03	1.86	1.90	2.03	1.85	2.09	2.71	2.73	2.56	2.21	2.10	2.19
a 64	1.81	1.60	1.67	1.69	1.85	2.03	2.09	2.10	2.25	1.99	1.80	1.65	1.89
a 65	1.47	1.46	1.33	1.77	2.26	2.67	2.90	3.07	3.06	2.87	2.34	2.09	2.28
a 66	1.74	1.53	1.53	1.98	2.23	2.43	2.71	2.94	2.67	2.68	2.36	2.47	2.27
a 67	2.20	2.09	1.90	2.13	2.12	2.72	3.05	3.03	3.01	2.99	2.58	2.34	2.59
a 68	2.08	1.49	1.85	2.04	2.44	2.35	2.57	2.49	2.62	2.80	2.73	2.32	2.30
a 69	2.10	1.86	1.41	1.99	2.39	2.49	2.77	3.23	4.05	3.56	3.22	2.57	2.83
a1870	2.32	2.11	2.12	2.22	2.85	2.86	2.85	2.72	2.56	2.38	1.45	1.23	2.22
a 71	1.36	0.76	1.18	1.66	2.21	2.53	2.40	2.46	2.86	2.40	2.42	1.66	1.96
72	1.47	1.36	1.24	1.14	1.79	2.17	2.44	2.61	2.77	2.67	2.52	2.22	2.09
73	2.12 c	1.80 c	1.82 c	1.88	2.31	2.61	2.90	3.08	3.14	3.04	2.90	2.60	2.53
74 c	2.14	2.13	2.09	2.19	2.26	2.48	2.84	2.93	3.03	3.00	2.91	2.60	2.56
75	2.28	2.24	2.28	2.28	2.50	2.88	2.85	2.94	3.17	3.02	2.88	2.66	2.69
76	2.48	2.27	2.18	2.21	2.73	3.43	3.82	3.93	3.82	3.49	3.32	3.05	3.00
77	2.69	2.45	2.19	2.11	2.10	2.32	2.70	2.76	2.90	2.60	2.39	2.22	2.44
78	2.20	2.32	1.85	1.52	1.79	2.07	2.14	2.02	1.85	1.92	1.72	1.40	1.89
79 c	1.49	1.48	1.76	1.37	1.01	1.24	1.48	1.60	1.49	1.58	1.50 c	1.14	1.42
1880 c	0.99 c	0.98 c	0.89 c	0.92 e	1.52	2.30	2.45	2.44	2.44	2.39	2.33	2.07	1.81
81	1.81	1.71	1.62	1.53	1.53	2.27	2.33	2.35	2.61	2.95	2.86	2.60	2.21
82	2.25	2.00	1.89	1.81	1.97	1.99	2.44	2.56	2.60	2.45	2.41	2.22	2.21
83	1.99	1.70	1.70	1.95	1.96	2.06	2.31	2.33	2.39	2.09	1.94	1.82	2.05
84 e	1.80 e	1.63 e	1.54	1.32	1.84	1.74	1.88	1.89	2.16	2.52	2.42	2.21	1.99
85	1.98	1.80	1.72	1.67	2.00	2.28	2.52	2.64	2.57	2.40	2.25	1.92	2.11
86	1.72	1.59	1.53	1.62	1.67	2.01	2.08	1.99	1.97	2.07	1.92	1.78	1.85
87	1.67	1.49	1.50	1.97	1.75	1.92	2.20	2.25	2.14	2.07	1.83	1.61	1.89
88	1.50	1.31	1.44	1.44	1.91	2.09	2.88	3.02	2.97	2.88	2.74	2.39	2.23
89	2.07	1.85	1.68	1.89	2.04	2.16	2.35	2.54	2.67	2.51	2.33	1.90	2.14
1890	1.76	1.63	1.39	1.36	1.57	2.02	2.32	2.47	2.60	2.57	2.36	2.00	2.09
91	1.64	1.51	1.47	1.43	1.63	1.98	1.88d	1.88d	1.82d	1.91d	1.79	1.43	1.67
92	1.42	1.14	1.01	1.02	1.35	1.73	1.76	1.88	1.93	1.82	1.66	1.38	1.61
93	1.16	1.01	1.06	1.16	1.66	2.18	2.48	2.54	2.48	2.42	2.26	2.03	1.89
94	1.85	1.67	1.76	1.91	2.06	2.91	2.97	3.10	3.02	3.04	2.99	2.86	2.54
95	2.80	2.98	2.11	2.01	2.28	2.76	2.90	2.95	3.09	3.14	2.85	2.53	2.63
96	2.32	2.12	1.92	2.01	2.66	3.04	3.10	3.12	2.95	2.93	2.70	2.55	2.80
97	2.39	2.16	2.08	2.11	2.43	2.78	3.06	3.20	3.14	2.94	2.64	2.21	2.66
98	1.83	1.68	1.46	1.46	1.70	2.18	2.59	2.72	2.82	2.76	2.66	2.32	2.17
99	1.98	1.76	1.79	1.76	2.47	2.95	3.19	3.35	3.51	3.32	3.21	3.00	2.96
1900	2.63	2.45	2.22	2.13	2.30	2.86	2.88	2.94	3.46	3.54	3.51	3.13	2.77
01	2.78	2.46	2.26	2.22	2.51	2.61	2.90	3.22	3.04	3.07	3.00	2.68	2.73
02	2.32	2.11	1.97	2.02	2.34	2.64	2.88	2.89	3.03	2.81e	2.81e	2.58	2.53
a 03	2.34	1.98	1.85	2.07	2.56	2.94	3.14	3.25	3.27	3.46	3.18	2.91	2.72
a 04	2.66	2.34	2.23	2.17	2.47	2.77	2.86	2.95	3.06	2.98	3.14	2.76	2.71
a 05	2.47	2.13	2.04	2.25	2.49	2.67	2.97	3.10	3.32	3.33	3.17	2.96	2.74
a 06	2.72	2.43	2.22	2.15	2.45	2.78	2.90	2.93	2.95	2.84	2.66	2.43	2.59
a 07	2.32	2.06	1.94	1.94	2.17	2.53	2.70	2.93	3.17	3.15	2.86	2.53	2.51
Mean	602.08	601.83	601.77	601.84	602.16	602.42	602.62	602.73	602.79	602.74	602.56	602.26	602.31

Authority, U. S. Lake Survey, except for supplied values.

a.—Gage readings taken at Superior, Wis.

b.—Supplied by applying to the mean reading, for the following or preceding month, the mean rise or fall in stage between such months for the years 1861 or 1862 to 1871, inclusive.

c.—Supplied by adding to the Sault Ste. Marie readings the mean fall in the water surface between Marquette and Sault Ste. Marie for the years 1871 to 1898, inclusive.

d.—Supplied in like manner from years 1899 to 1901, inclusive.

e.—From self-registering gage.

NOTE.—Elevations depend on zero of gage 601.75 ft. and B. M. 3,009.91 ft., U. S. Lake Survey, 1903 Levels.

TABLE 3.

WATER LEVELS OF ST. MARYS RIVER.

Monthly mean elevations of water surface of St. Marys River, at Southwest pier (above the locks) Sault Ste. Marie, Mich., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	602.22	601.95	601.93	602.13	602.55	602.74	602.74	602.80	602.72	602.76	602.88	602.18	602.45
a 61	1.93	1.68	1.52	1.91	2.48	2.85	3.05	3.02	2.87	2.90	2.55	2.12	2.42
a 62	1.72	1.51	1.54	1.58	2.40	2.41	2.42	2.60	2.66	2.59	2.25	1.91	2.13
a 63	1.69	1.54	1.37	1.39	1.66	1.93	1.78	2.41	2.37	2.20	1.84	1.68	1.79
a 64	1.34	1.11	1.13	1.13	1.43	1.65	1.72	1.80	1.89	1.63	1.43	1.23	1.48
a 65	1.00	0.97	0.84	1.26	1.89	2.32	2.66	2.77	2.72	2.51	1.97	1.61	1.85
a 66	1.27	1.04	1.04	1.47	1.86	2.07	2.46	2.64	2.31	2.33	1.99	2.06	1.87
a 67	1.73	1.60	1.41	1.61	1.75	2.37	2.74	2.63	2.65	2.63	2.19	1.82	2.09
a 68	1.61	1.60	1.36	1.53	2.07	2.00	2.26	2.19	2.26	2.22	2.35	1.90	1.99
a 69	1.63	1.37	0.92	1.42	2.02	2.05	2.46	2.93	2.72	3.20	2.85	2.15	2.23
1870 c	1.85 c	1.62 c	1.63 c	1.71 c	2.18 c	2.01 c	2.24 c	2.25 c	2.36 c	2.20	2.01	1.63	1.92
71	1.36	1.20	0.93	1.07	1.64	2.08	2.28	2.18	2.20	2.03	1.78	1.39	1.67
72	1.14	1.06	0.82	0.78	1.67	1.84	2.24	2.56	2.63	2.48	2.32	1.88	1.79
73	1.48	1.31	1.33	1.35	1.91	2.04	2.48	2.73	2.80	2.68	2.46	2.22	2.07
74	1.67	1.51	1.40	1.28	1.70	2.13	2.50	2.56	2.54	2.67	2.43	2.35	2.06
75	1.89	1.64	1.60	1.55	2.16	2.46	2.54	2.56	2.84	2.71	2.43	1.87	2.21
76	1.84	1.79	1.53	1.57	2.29	2.57	3.34	3.39	3.42	3.09	2.81	2.32	2.52
77	2.08	2.06	1.94	1.62	1.82	2.04	2.37	2.49	2.25	2.39	2.05	1.89	2.09
78	1.67	1.41	1.31	1.29	1.57	1.83	1.94	1.90	1.61	1.72	1.64	1.42	1.61
79	1.02	0.62	0.38	0.61	0.88	1.02	1.32	1.35	1.27	1.30	1.12	0.72	0.96
1880	0.52	0.49	0.40	0.41	1.15	1.91	2.15	2.02	2.19	1.98	1.90	1.71	1.41
81	1.48	1.30	1.32	1.21	1.63	1.86	2.06	1.98	2.17	2.63	2.53	2.20	1.86
82	1.69	1.47	1.35	1.30	1.71	1.80	2.15	2.25	2.19	2.10	2.04	1.77	1.82
83	1.34	1.25	1.25	1.32	1.31	1.68	1.86	2.26	1.95	1.80	1.60	1.43	1.60
84	1.23	1.14	1.05	0.88	1.25	1.35	1.57	1.61	1.68	1.77	1.57	1.61	1.43
85	1.44	1.23	1.19	1.02	1.66	1.94	2.12	2.34	2.10	1.92	1.83	1.55	1.70
86	1.20	1.04	1.04	1.02	1.50	1.66	1.83	1.97	1.82	1.86	1.79	1.36	1.51
87	1.14	1.00	0.97	0.83	1.19	1.64	2.01	1.89	1.73	1.93	1.70	1.39	1.44
88	1.13	0.79	0.84	0.83	1.43	2.28	2.44	2.43	2.35	2.34	2.14	1.80	1.73
89	1.52	1.23	1.26	1.25	1.81	1.99	2.26	2.27	2.26	2.11	1.81	1.43	1.77
1890	1.48	0.93	0.92	0.85	1.32	1.90	2.29	2.17	2.06	1.99	1.88	1.55	1.61
91	0.86	0.97	0.82	1.00	1.43	1.28	1.49	1.50	1.43	1.49	1.28	1.07	1.24
92	1.01	0.68	0.47	0.93	1.14	1.52	1.64	1.65	1.71	1.60	1.32	1.04	1.20
93	0.79	0.59	0.60	0.85	1.42	1.95	2.15	2.23	2.10	2.04	1.90	1.45	1.51
94	1.23	1.15	1.04	1.42	2.40	2.64	2.78	2.79	2.66	2.70	2.60	2.30	2.14
95	2.00	1.86	1.68	1.64	2.04	2.42	2.57	2.66	2.65	2.97	2.48	2.24	2.29
96	1.60	1.68	1.46	1.57	2.18	2.59	2.72	2.74	2.61	2.18	2.21	2.15	2.15
97	1.92	1.61	1.63	1.76	2.11	2.47	2.69	2.85	2.66	2.47	2.36	1.87	2.20
98	1.58	1.16	1.00	1.13	1.43	1.83	2.17	2.26	2.49	2.26	2.00	2.01	1.76
99	1.53	1.37	1.26	1.26	2.12	2.56	2.76	2.91	2.16	2.77 b	2.86 b	2.64	2.25
b1900	2.03	1.90	1.64	1.68	1.87	1.94	2.17	2.26	2.90	2.85	3.04	2.62	2.24
b 01	2.17	1.87	1.63	1.76	2.06	2.15	2.59	2.74	2.63	2.73	2.82	2.27	2.27
b 02	2.00	1.61	1.53	1.66	1.86	2.39	2.48	2.46	2.54	2.39	2.48	2.29	2.13
b 03	1.83	1.90	1.51	1.76	2.15	2.57	2.70	2.80	2.83	2.98	2.86	2.41	2.33
b 04	1.87	1.64	1.40	1.76	2.06	2.34	2.48	2.55	2.65	2.83	2.71	2.30	2.21
b 05	2.00	2.59	1.38	1.73	2.07	2.35	2.60	2.72	2.92	2.96	2.72	2.52	2.39
b 06	2.18	1.58	1.63	1.70	2.02	2.20	2.50	2.46	2.46	2.38	2.13	1.96	2.13
b 07	1.62	1.43	1.34	1.69	1.71	2.13	2.33	2.50	2.70	2.71	2.54	2.08	2.08
Mean	601.58	601.34	601.24	601.35	601.80	602.06	602.31	602.40	602.41	602.33	602.15	601.86	601.91

Authority, U. S. Lake Survey, except for supplied values.

a.—Values supplied by subtracting from the Superior, Wis., readings the mean fall in water surface between Superior and Sault Ste. Marie for the years 1860 to November, 1870, inclusive.

b.—From self-registering gage.

Note.—Elevations depend on B. M. "A" 606.089 ft., U. S. Lake Survey, 1903 Levels.

TABLE 4.

WATER LEVELS OF LAKE MICHIGAN.

Monthly mean elevations of water surface of Lake Michigan, at Milwaukee, Wis., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	581.51	581.60	581.73	581.85	581.97	581.60	581.13	581.94	581.74	581.43	581.10	581.04	581.63
61	1.30	1.02	2.31	2.41	2.52	2.90	2.13	2.26	2.06	2.06	2.70	2.52	2.40
62	2.33	2.18	2.48	2.64	2.80	3.02	2.92	2.91	2.84	2.73	2.84	2.80	2.73
63	2.13	2.18	2.17	2.17	2.32	2.47	2.43	2.29	2.11	2.05	1.85	1.92	2.15
64	1.90	1.85	1.80	1.81	2.00	2.01	1.91	1.79	1.48	1.07	0.90	0.77	1.56
65	0.56	0.65	0.82	1.21	1.47	1.81	1.94	1.96	1.88	1.03	1.04	0.72	1.39
66	0.47	0.29	0.38	0.79	0.91	1.20	1.43	1.62	1.27	1.16	1.17	0.91	0.96
67	0.80	0.94	1.13	1.41	1.68	1.94	2.09	2.06	1.73	1.42	0.96	0.61	1.40
68	0.45	0.41	1.00	0.99	1.37	1.42	1.51	1.17	0.62	0.70	0.62	0.32	0.92
69	0.36	0.32	0.06	0.48	0.78	1.20	1.37	1.05	1.02	1.46	1.34	1.06	0.93
1870	1.12	1.31	1.51	1.95	2.27	2.41	2.45	2.42	2.27	2.17	1.77	1.42	1.96
71	1.37	1.49	2.09	2.20	2.64	2.66	2.71	2.46	1.81	1.12	1.03	0.46	1.87
72	0.35	0.25	0.13	0.35	0.63	1.03	1.03	1.01	0.94	0.82	0.33	579.87	0.59
73	579.87	579.91	0.33	0.79	1.35	1.80	1.94	2.04	1.85	1.79	1.36	581.33	1.25
74	581.48	581.77	1.92	1.82	1.81	2.17	2.16	2.11	1.89	1.51	1.31	0.97	1.75
75	0.77	0.70	0.76	1.12	1.66	1.96	1.99	2.06	1.99	1.94	1.62	1.44	1.49
76	1.39	1.49	1.63	2.13	2.74	3.15	3.40	3.42	3.27	2.72	2.36	2.43	2.62
77	2.28	2.29	2.39	2.67	2.84	3.05	3.04	3.40	3.27	3.26	2.16	2.10	2.80
78	1.96	1.91	2.07	2.09	2.29	2.53	2.64	2.32	2.03	1.91	1.75	1.46	2.05
79	1.15	1.18	1.50	1.19	1.21	1.39	1.46	1.28	1.17	0.93	0.73	0.76	1.15
1880	0.80	0.71	0.73	0.93	1.26	1.77	1.99	2.05	1.73	1.35	1.06	0.98	1.29
81	0.90	1.11	1.40	1.31	1.62	2.02	2.05	2.05	1.78	1.12	1.03	1.02	1.53
82	1.63	1.62	1.80	2.12	2.52	2.89	2.93	2.91	2.66	2.36	2.07	1.76	2.13
83	1.48	1.62	1.61	1.82	2.30	2.64	2.56	2.52	2.04	2.02	2.37	2.30	2.07
84	2.07	2.19	2.44	2.62	2.85	3.06	2.93	3.06	2.44	2.44	2.06	2.05	2.57
85	2.00	2.09	2.25	2.44	2.80	3.01	3.15	3.31	3.17	3.06	2.72	2.44	2.72
86	2.57	2.60	2.97	3.21	3.61	3.87	3.88	3.13	2.91	2.81	2.47	2.14	3.00
87	2.00	2.43	2.89	2.64	2.74	2.97	2.81	2.67	2.23	1.86	1.55	1.42	2.23
88	1.25	1.20	1.33	1.50	1.97	2.54	2.32	2.13	1.96	1.72	1.46	1.16	1.71
89	1.08	1.05	1.05	1.04	1.15	1.88	1.79	1.85	1.53	1.10	0.75	0.57	1.24
1890	0.45	0.61	0.89	0.91	1.14	1.65	1.62	1.54	1.34	1.26	0.96	0.84	1.09
91	0.59	0.38	0.47	0.78	0.89	1.03	0.96	0.78	0.56	0.20	579.96	579.74	0.69
92	579.86	0.06	579.96	0.01	0.43	0.80	0.85	0.97	0.77	0.53	580.26	0.99	0.56
93	0.96	0.12	580.23	0.66	0.90	1.23	1.34	1.17	0.93	0.71	0.33	580.20	0.84
94	580.10	0.29	0.55	0.70	1.04	1.45	1.43	1.38	0.92	0.72	0.44	0.06	0.77
95	579.91	579.80	579.77	579.97	0.12	0.18	0.07	579.96	579.66	579.51	579.05	578.96	579.78
96	9.06	9.10	9.11	9.26	579.87	579.89	579.82	9.76	9.66	9.51	9.30	9.24	9.47
97	9.23	9.41	9.72	9.89	580.25	580.45	580.34	580.78	580.53	580.24	9.96	9.78	580.13
98	9.72	9.96	580.18	580.30	0.76	0.91	0.69	0.66	0.34	0.32	9.92	9.58	9.81
99	9.33	9.61	579.81	0.06	0.53	0.83	1.04	0.96	0.83	0.46	580.31	9.81	0.52
1900	9.00	9.77	9.96	0.07	0.31	0.45	0.53	0.79	0.46	0.46	0.53	580.10	0.29
01	9.94	9.92	580.24	0.49	0.92	0.97	1.06	1.11	0.93	0.84	0.22	579.98	0.64
02	9.76	9.61	579.64	579.91	0.20	0.50	0.82	0.45	0.32	0.33	0.03	9.91	0.22
03	9.66	9.39	580.06	580.33	0.42	0.61	0.79	0.72	0.77e	0.94e	0.14e	9.86	0.31
e 04	9.90	9.96	0.14	0.60	0.96	1.35	1.36	1.20	1.19	1.06	0.75	580.44	0.74
e 05	580.27	580.21	0.33	0.71	0.97	1.36	1.54	1.51	1.41	0.97	0.71	0.53	0.86
06e	0.52e	0.86e	0.92e	1.01	1.37	1.39	1.44	1.41	1.09	0.96	0.85	0.66	0.99
07	0.60	0.64	0.70	0.96	1.15	1.46	1.48	1.38	1.37	1.16	0.74	0.62	1.00
Mean	580.94	580.87	581.04	581.24	581.45	581.77	581.84	581.79	581.66	581.37	581.13	580.96	581.32

Authority, U. S. Lake Survey.

e.—Self-registering gage on harbor pier.

Note.—Elevations depend on check point (1876) on Chestnut St. Bridge (destroyed) as 595.58 ft. and check point (1902) on same bridge as 584.47 ft., U. S. Lake Survey, 1903 Levels.

TABLE 5.

WATER LEVELS OF LAKE HURON.

Monthly mean elevations of water surface of Lake Huron, at Harbor Beach, Mich., in feet above mean tide at New York.

Year.	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	582.32	582.73	582.93	582.96	582.94	582.15	582.27	582.19	582.00	582.42	582.50	582.20	582.56
61	1.98	2.05	2.17	2.37	2.09	2.23	2.45	2.56	2.48	2.96	2.95	2.82	2.57
62	2.44	2.42	2.84	2.55	2.92	2.91	2.99	3.07	2.85	3.13	2.81	2.82	2.77
63	2.76	2.21	2.16	2.32	2.55	2.68	2.89	2.60	2.46	2.20	2.18	1.93	2.34
64	1.78	1.78	1.75	1.93	2.35	2.39	2.24	2.23	1.91	1.86	1.21	1.06	1.85
65	0.72	0.81	0.92	1.47	1.68	1.67	2.10	2.12	2.00	1.76	1.20	0.89	1.45
66	0.62	0.39	0.44	0.88	1.07	1.36	1.62	1.68	1.53	1.42	1.33	1.07	1.12
67	1.00	1.10	1.23	1.57	1.79	2.10	2.22	2.19	1.91	1.58	1.12	0.77	1.56
68	0.61	0.57	1.25	1.13	1.42	1.64	1.67	1.33	1.09	0.86	0.79	0.51	1.06
69	0.41	0.45	0.22	0.58	0.92	1.45	1.82	2.09	1.96	1.62	1.50	1.22	1.19
1870	1.28	1.37	1.67	2.00	2.43	2.87	2.98	3.59	2.73	2.33	1.93	1.86	2.10
71	1.73	1.68	2.25	2.43	2.90	2.84	2.87	2.56	2.21	1.74	1.53	1.16	2.15
72	0.96	0.79	0.39	0.71	1.11	1.51	1.61	1.58	1.46	1.36	1.06	0.77	1.10
73	0.60	0.57	0.64	1.06	1.55	1.95	2.15	2.16	1.99	1.96	1.80	1.70	1.62
74	1.72	1.98	2.00	1.82	1.90	2.26	2.40	2.29	2.11	1.84	1.30	1.46	1.91
75	1.16	1.15	1.14	1.32	1.66	1.90	2.18	2.15	2.19	2.00	1.80	1.62	1.70
76	1.74	1.72	1.85	2.13	2.73	3.22	3.06	3.80	3.49	3.09	2.94	2.75	2.74
77	2.46	2.45	2.38	2.46	2.62	2.89	2.77	2.67	2.40	2.36	2.21	2.16	2.45
78	2.06	1.96	2.00	1.99	2.30	2.58	2.60	2.50	2.21	2.22	2.05	1.83	2.20
79	1.53	1.26	1.28	1.26	1.41	1.55	1.59	1.46	1.38	1.14	1.02	1.00	1.32
1880	1.05	0.99	0.96	0.99	1.39	1.88	2.19	2.08	1.97	1.61	1.49	1.39	1.49
81	1.16	1.55	1.56	1.55	1.90	2.07	2.22	2.05	1.89	2.14	2.27	2.10	1.87
82	1.93	1.72	1.88	2.08	2.25	2.48	2.62	2.66	2.56	2.23	2.08	1.93	2.21
83	1.73	1.66	1.72	1.73	2.30	2.72	2.53	2.40	2.08	2.75	2.80	2.75	2.40
84	2.56	2.41	2.45	2.76	2.96	3.04	3.12	3.00	2.85	2.81	2.46	2.30	2.70
85	2.47	2.38	2.28	2.49	2.89	3.19	3.26	3.39	3.39	3.06	2.87	2.67	2.86
86	2.67	2.74	2.95	3.22	3.55	3.64	3.46	3.53	3.15	3.02	2.75	2.43	3.08
87	2.26	2.45	2.66	2.57	2.77	2.80	2.97	2.76	2.41	2.19	1.74	1.45	2.43
88	1.36	1.25	1.42	1.56	2.00	2.30	2.33	2.27	2.08	1.78	1.60	1.98	1.78
89	1.23	1.17	1.15	1.06	1.32	1.58	1.81	1.75	1.58	1.31	0.97	0.71	1.30
1890	0.78	0.66	0.64	0.78	1.08	1.53	1.71	1.71	1.44	1.23	1.03	0.73	1.11
91	0.53	0.42	0.39	0.72	0.96	0.91	0.94	0.84	0.65	0.36	579.97	579.91	0.64
92	579.90	579.87	579.89	0.05	0.14	0.67	0.96	1.01	0.87	0.66	580.23	580.09	0.55
93	9.84	9.79	9.87	0.25	0.86	1.21	1.33	1.21	0.91	0.73	0.47	0.30	0.87
94	580.22	580.24	580.30	0.62	1.05	1.32	1.47	1.30	1.01	0.77	0.58	0.38	0.76
95	579.96	579.94	579.85	579.95	0.12	0.19	0.16	0.07	579.94	579.65	579.36	579.09	579.83
96	9.00	9.31	9.11	9.14	579.84	579.91	579.97	0.01	9.82	9.62	9.49	9.35	9.83
97	9.45	9.36	9.47	9.84	580.41	580.65	580.82	0.84	580.53	580.23	580.07	9.81	580.13
98	9.66	9.72	9.95	580.44	0.86	0.72	0.82	0.71	0.53	0.31	0.13	9.94	0.38
99	9.96	9.84	9.98	579.36	0.40	0.79	1.06	0.98	0.79	0.58	0.34	580.03	0.39
1900	9.83	9.83	9.96	9.98	0.13	0.20	0.85	0.64	0.72	0.46	0.26	0.04	0.30
01	580.22	580.06	580.07	a580.55	0.81 a	0.91 a	1.06 a	1.11 a	0.85 a	0.66 a	0.43 a	0.16	0.57
a 02	0.00	579.81	579.73	579.91	0.16	0.46	0.78	0.82	0.61	0.27	0.17	579.93	0.22
a 03	579.74	9.78	9.93	580.27	0.39	0.56	0.75	0.75	0.60	0.63	0.41	580.13	0.36
a 04	9.91	9.91	580.05	0.62	0.96	1.45	1.55	1.53	1.38	1.26	0.95	0.80	0.84
a 05	580.38	580.30	0.39	0.66	0.95	1.40	1.57	1.56	1.45	1.23	0.93	0.67	0.95
a 06	0.53	0.46	0.76	0.94	1.30	1.52	1.42	1.36	1.12	0.87	0.66	0.48	0.96
a 07	0.46	0.46	0.66	0.94	1.08	1.39	1.64	1.40	1.42	1.31	0.83	0.62	1.05
Mean.	581.02	580.99	581.06	581.26	581.57	581.83	581.97	581.92	581.75	581.53	581.31	581.09	581.44

Authority, U. S. Lake Survey (see page 4105, appendix EEE, Annual Report of the Chief of Engineers for 1904).

a—Self-registering gage.

Note.—Elevations depend on gage bolt "E" 583.21 ft., B. M. "Jenks" 610.56 ft., U. S. Lake Survey, 1900 Levels.

TABLE 6.

WATER LEVELS OF ST. CLAIR RIVER.

Monthly mean elevations of water surface of St. Clair River, at Grand Trunk Railway (G. T. R.), in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mea
a1860	583.06	582.92	582.14	581.82	581.86	582.09	582.16	582.06	581.92	581.58	581.47	581.20	581.87
a 61	1.31	1.35	1.47	1.36	1.91	2.21	2.32	2.41	2.34	2.15	1.87	1.76	1.97
a 62	1.71	1.70	1.62	1.52	1.84	1.95	2.00	1.98	1.79	2.03	1.75	1.49	1.79
a 63	1.04	1.51	..66	1.23	1.52	1.63	1.55	1.56	1.44	1.20	1.17	0.98	1.41
a 64	1.14	1.10	1.10	0.98	1.36	1.37	1.32	1.32	0.95	0.48	0.32	0.31	0.96
a 65	0.18	0.20	0.42	0.56	0.70	0.73	1.13	1.13	1.09	0.81	0.32	0.04	0.61
a 66	0 10	579.89	579.93	0 03	0.20	0.46	0.69	0.74	0.61	0.51	0.43	0.32	0.53
a 67	0.48	580.52	580.68	0.64	0.84	1.12	1.25	1.19	0.95	0.65	0.24	579.93	0.71
a 68	0.08	0.08	0.56	0.27	0.52	0.71	0.73	0.43	0.22	0.01	579.94	9.70	0.37
a 69	579.91	579.97	579.74	579.77	0.07	0.54	0.88	1.11	1.01	0.99	580.58	580.33	0.98
a1870	580.68	580.78	581.03	581.11	1.41	1.53	1.63	1.55	1.08	1.32	0.96	0.80	1.19
a 71	1.06	1.01	1.84	1.43	1.74	1.77	1.80	1.52	1.24	0.80	0.61	0.26	1.34
a 72	0.42	0.25	579.80	579.88	0.24	0.56	0.66	0.65	0.56	0.46	0.19	579.95	0.39
a 73	0.08	0.05	580.11	580.18	0.63	0.95	1.16	1.17	1.02	0.99	0.90	580.76	0.67
a 74	1.07	1.20	1.25	0.89	0.94	1.34	1.38	1.25	1.12	0.88	0.40	0.34	1.02
a 75	0.57	0.52	0.56	0.43	0.74	1.05	1.19	1.16	1.20	1.05	0.65	0.62	0.84
a 76	1.09	1.07	1.10	1.14	1.66	2.11	2.50	2.48	2.25	2.09	1.66	1.69	1.79
a 77	1.73	1.72	1.66	1.44	1.59	1.85	1.71	1.62	1.38	1.26	1.21	1.17	1.59
a 78	1.38	1.32	1.38	1.02	1.37	1.52	1.56	1.47	1.21	1.22	1.05	0.88	1.27
a 79	0.90	0.89	0.66	0.38	0.80	0.63	0.66	0.55	0.49	0.28	0.16	0.14	0.59
a1880	0.48	0.42	0.42	0.13	0.46	0.92	1.20	1.10	1.00	0.66	0.57	0.40	0.65
a 81	0.58	0.92	0.93	0.65	0.94	1.06	1.22	1.07	0.93	1.15	1.27	1.12	0.99
a 82	1.26	1.07	1.20	1.10	1.25	1.43	1.55	1.63	1.52	1.23	1.10	0.92	1.29
a 83	1.06	1.04	1.07	0.79	1.20	1.67	2.09	2.27	1.99	1.69	1.79	1.69	1.61
a 84	1.82	1.88	1.72	1.70	1.90	1.95	2.02	1.92	1.60	1.75	1.44	1.26	1.78
a 85	1.74	1.86	1.66	1.46	1.85	2.08	2.13	2.26	2.17	1.97	1.80	1.63	1.88
a 86	1.92	1.98	2.18	2.11	2.41	2.49	2.34	2.24	2.08	1.93	1.80	1.41	2.08
a 87	1.55	1.72	1.91	1.53	1.71	1.82	1.99	1.70	1.39	1.20	0.80	0.54	1.48
a 88	0.76	0.96	0.81	0.64	1.05	1.29	1.32	1.36	1.09	0.83	0.67	0.48	0.91
a 89	0.66	0.88	0.57	0.21	0.33	0.63	0.88	0.80	0.55	0.33	0.02	579.88	0.45
a1890	0.24	0.13	0.11	579.94	0.22	0.60	0.77	0.77	0.53	0.34	0.16	9.90	0.21
a 91	0.01	579.93	579.89	9.89	0.10	0.06	0.06	0.00	579.83	579.80	579.53	9.17	579.91
a 92	579.48	9.42	9.46	9.36	579.37	579.84	0.10	0.17	580.09	9.84	9.84	9.39	9.68
a 93	9.40	9.36	9.42	9.47	580.03	580.70	0.48	0.33	0.07	0.88	9.68	9.80	9.88
a 94	9.78	9.76	9.86	9.80	0.16	0.42	0.58	0.33	0.15	9.93	9.76	9.87	580.00
a 95	9.87	9.48	9.47	9.37	579.46	579.48	579.45	579.37	579.26	9.00	8.65	8.44	579.38
a 96	8.80	8.90	8.81	8.58	8.90	9.22	9.26	9.22	9.16	8.98	8.86	8.78	8.96
a 97	9.12	9.04	9.16	9.17	9.66	9.90	580.05	580.06	9.82	9.42	9.41	9.14	9.51
a 98	9.30	9.36	9.56	9.70	9.81	9.95	0.04	579.94	9.77	9.50	9.42	9.26	9.68
Yea	9.32a	9.20b	9.33b	9.21b	9.58	580.02b	0.20	580.24	580.05b	9.90b	9.47b	9.28	9.62
b1900	9.39	9.47	9.47	9.22	9.42	579.56	579.80	579.87	579.85	9.77	9.73	9.82	9.69
b 01	9.87	9.76	9.88	580.05	9.99	9.96	580.17	580.26	580.02	9.79	9.88	9.82	9.94
b 02	9.83	9.84	9.95	579.11	9.22	9.63	579.95	0.01	579.73	9.55	9.35	9.16	9.47
b 03	9.37	9.44	9.26	9.52	9.86	9.77	9.90	579.93	9.96	9.94	9.84	9.41	9.64
b 04	9.46	9.56	9.34	9.09	580.12	580.33	580.56	580.55	580.46	580.32	580.07	9.77	580.06
b 05	580.16	580.07	9.79	9.52	9.07	9.56	9.76	9.70	9.57	9.31	9.04	580.78	9.80
b 06	579.75	9.30	580.23	580.11	9.39	9.38	9.57	9.49	9.27	9.04	579.86	9.07	9.39
b 07	580.13	9.89	9.12	9.06	9.22	9.49	9.66	9.63	9.53	9.33	9.90	579.74	9.77
Mean	580.46	580.42	580.46	580.38	580.66	580.86	581.00	580.97	580.81	580.61	580.41	580.26	580.61

Authority, U. S. Lake Survey, except for supplied values.

a.—Supplied from Harbor Beach readings for the summer months, April to December, inclusive, by formula (G. T. R.—578)—0.880 (Harbor Beach—578)—0.530; and for winter months January to March, inclusive, by formula (G. T. R.—578)—0.880 (Harbor Beach—578)—0.235.

b.—Self-registering gage.

Note.—Elevations depend on B. M. Fort Gratiot Light-house (1877) as 860.343 ft., U. S. Lake Survey, 1903 Levels.

TABLE 7.

WATER LEVELS OF LAKE ST. CLAIR.

Monthly mean elevations of water surface of Lake St. Clair, at the St. Clair Flats Canal, in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	576.31	574.86	575.94	576.80	576.98	577.03	576.40	576.30	575.90	576.20	575.66	576.20	576.22
b 61	6.37	4.92	6.02	6.77	6.82	7.03	7.00	7.17	6.98	6.78	6.64	6.64	6.90
b 62	6.29	5.14	6.07	7.24	7.24	7.26	7.27	7.15	6.94	6.74	6.43	6.30	6.87
b 63	6.45	6.41	6.16	6.83	6.90	6.77	6.83	6.79	6.61	6.11	5.94	5.90	6.46
b 64	6.14	5.80	5.61	6.30	6.70	6.90	6.87	6.47	6.29	5.80	5.72	5.83	6.16
65b	4.53b	3.78b	4.48b	5.04b	6.17b	6.31b	6.40c	6.38c	6.32c	6.11c	5.66c	5.62	5.80
66b	5.43c	4.91c	4.96c	5.72c	5.84c	6.12c	6.20c	6.24c	6.18c	6.16c	6.03c	6.30	5.85
c 67	5.30	5.26	5.52	6.06	6.46	6.84	6.70	6.61	6.25	5.90	5.42	5.30	5.91
68d	5.37d	4.15d	5.43c	5.64c	6.10c	6.41c	6.34c	6.00c	5.78c	5.40c	5.15c	5.12	5.57
69d	4.81d	4.20d	4.88c	5.35c	5.66c	6.00c	6.48c	6.49c	6.26c	5.87c	5.60d	5.93	5.60
1870d	6.70d	5.52d	5.52c	6.26c	6.74c	6.86c	7.04c	6.96c	6.74c	6.34c	6.11c	6.10	6.42
71d	5.71d	4.71c	5.40c	5.45c	6.72c	6.76c	6.82c	6.62c	6.36c	5.76c	5.60d	5.83	6.15
72d	5.00d	4.86d	4.70c	5.12c	5.32c	5.74	5.47	5.61	5.47	5.48	4.96	4.92	5.24
73	4.42	4.62	4.99	5.67	5.99	6.16	6.20	6.26	6.06	5.61	5.62	5.83	5.66
74	5.05	4.41	5.84	6.07	6.02	6.26	6.43	6.31	6.10	5.86	5.57	5.26	5.76
75	5.11	5.04	5.20	5.71	5.78	5.94	6.12	6.11	5.96	5.79	5.61	5.51	5.82
76	5.66	5.11	6.00	6.05	6.03	7.13	7.08	7.51	7.04	6.71	6.80	7.45	6.69
77	6.98	5.52	6.24	6.30	6.43	6.26	6.53	6.44	6.19c	6.13	6.24	6.08	6.24
78	5.96	5.00	5.16b	5.47b	6.03	6.06	6.03	6.71	6.37	6.18	5.85	5.61	6.12
79	5.30	4.51	5.20	5.75	5.93b	5.94b	6.01b	5.80b	5.61b	5.33b	5.03b	5.25	5.43
b1880	5.52	5.07	5.00	5.66	5.84	6.03	6.19	6.27	6.03	5.68	5.51	6.18	5.81
81b	4.60b	5.05b	5.05b	5.67b	6.01b	6.31b	6.23b	6.20	6.07	5.87c	6.00c	6.13	5.77
82c	6.40c	6.05c	6.53c	6.87	6.96c	6.81	7.41	7.40c	6.78c	6.48	6.17c	6.67	6.66
83c	6.26c	6.00c	5.96c	6.05	6.34	7.07	7.74	7.66	7.20	6.82	6.39	6.34	6.60
84	4.93	5.35	6.75	6.96	7.18	7.23	7.36	7.09	6.73	6.31	6.14	6.23	6.56
85	6.52	6.02	6.86	6.86	6.73	7.10	7.01	7.12	6.97	6.65	6.61	6.59	6.75
86	6.75	6.46	6.64	6.80	6.99	7.04	7.05	6.98	6.78	6.62	6.28	6.55	6.80
87	6.34	6.35	6.33	6.55	6.77	6.86	6.66	6.68	6.40	6.07	5.65	5.61	6.37
88	5.67	5.45	5.16	5.81	5.83	6.04	6.33	6.23	5.99	5.71	5.58	5.47	5.77
89	5.71	4.77	4.63	4.96	5.38	5.91	6.03	5.90	5.70	5.31	5.03	4.96	5.36
1890	5.44	5.36	5.38	5.68	5.91	6.34	6.27	6.03	5.79	5.57	5.34	5.30	5.71
91	4.97	5.07	4.68	5.23	5.12	5.39	5.36	5.23	5.12	4.80	4.56	4.64	5.03
92	4.58	3.81	3.70	4.53	5.07	5.60	5.68	5.71	5.60	5.15	4.76	4.54	4.87
93	3.70	3.90	4.04	5.07	5.45	5.82	5.86	5.66	5.42	5.16	4.88	4.96	5.04
94	4.99	4.49	4.86	5.01	5.44	5.69	5.72	5.23	5.35	5.12	4.86	4.82	5.16
95	5.23	5.20	4.96	4.19	4.46	4.52	4.66	4.66	4.53	4.12	3.84	4.12	4.54
96	4.17	3.23	3.57	4.00	4.34	4.70	4.87	5.03	4.71	4.61	4.15	4.13	4.31
97	4.43	4.77	4.72	4.77	5.18	5.26	5.43	5.40	5.14	4.78	4.61	4.64	4.93
98	4.38	4.10	4.72	5.17	5.26	5.49	5.54	5.40	5.13	4.87	4.82	4.90	5.00
99	4.90	4.87	4.53	4.68	5.07	5.34	5.51	5.45	5.14	4.84	4.71	4.65	4.94
1900	4.18	4.29	4.77	4.87	4.96	5.16	5.23	5.28	5.16	5.01	4.88	4.74	4.88
01	4.80	3.62	3.96	3.17	4.27	4.05	3.36	3.24	3.22	4.90	4.51	4.64	4.55
02f	3.70f	3.39f	4.26	4.46	4.70	5.07	5.70	5.80	5.28	5.18	4.89	4.99	4.76
03	5.19f	4.72f	5.06f	5.57	5.34	5.46	5.65	5.54	5.53	5.29	4.89	5.30	5.30
04	4.13	4.44	3.68	5.03	5.03	6.12	6.16	6.09	5.92	5.65	5.28	5.29	5.34
05	4.44	4.14	4.78	5.06	5.38	5.52	6.01	5.95	5.78	5.54	5.26	5.11	5.27
06f	5.25f	4.32f	4.20f	5.26f	5.40f	5.61f	5.81f	5.76f	5.55f	5.37	5.44	5.33	5.27
07	5.40	4.96	5.02	5.64	5.78	6.11	6.27f	5.96f	5.76f	5.66f	5.35f	5.32	5.62
Mean	576.30	574.85	575.20	575.64	576.00	576.17	576.28	576.19	575.96	575.72	575.46	575.89	755.66

Authority, U. S. Lake Survey, except for supplied values.

a.—Deduced by subtracting 0.67 foot from St. Clair Flats values (U. S. L. S. Report, 1904), to obtain original values at Old Detroit Water Works, then supplying by formula (Fall St. Clair Flats to Amherstburg) — 0.9878 (Fall Old Detroit Waterworks to Amherstburg) + 0.883.

b.—Supplied by formula (Fall St. Clair Flats to Amherstburg) — 1.0357 (Fall Light-house Depot to Amherstburg) + 0.377.

c.—Supplied by using mean of two values derived from equations (Fall St. Clair Flats to Amherstburg) — 0.9878 (Fall Old Detroit Waterworks to Amherstburg) + 0.883; and (Fall St. Clair Flats to Amherstburg) — 1.0357 (Fall Light-house Depot to Amherstburg) + 0.377.

d.—Supplied by formula (Fall St. Clair Flats to Amherstburg) — 0.9878 (Fall Old Detroit Waterworks to Amherstburg) + 0.883.

e.—Derived by first subtracting 0.477 foot from New Detroit Waterworks' readings and then applying the mean monthly fall from St. Clair Flats to New Detroit Waterworks, as deduced from observations taken at those points from January, 1899, to June, 1901, inclusive.

f.—Derived from observations taken at Windmill Point by applying the mean monthly fall from St. Clair Flats Canal to Windmill Point as determined from simultaneous observations taken at those points from January, 1897, to July, 1907, inclusive.

Note.—Elevations depend on zero of gage 573.56 ft., and P. B. M., "Upper Light," 581.76 ft., U. S. Lake Survey, 1903 Levels.

TABLE 8.

WATER LEVELS OF LAKE ST. CLAIR.

Monthly mean elevations of water surface of Lake St. Clair, at Windmill Point, near the outlet of Lake St. Clair, in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	574.92	574.51	575.04	576.24	576.69	576.64	576.17	576.06	575.66	576.30	575.98	575.93	575.96
a 61	5.96	4.60	5.72	6.51	6.63	6.84	6.77	6.95	6.72	6.49	6.34	6.26	6.72
a 62	5.90	4.81	5.77	6.98	7.04	7.09	7.04	6.93	6.69	6.45	6.13	5.94	6.49
a 63	6.09	6.08	5.84	6.27	6.70	6.82	6.90	6.67	6.38	5.62	5.64	5.54	6.13
a 64	5.73	5.17	5.51	6.04	6.50	6.71	6.44	6.25	6.04	5.51	5.49	5.47	5.93
a 65	4.14	3.48	4.12	5.32	5.97	6.02	6.17	6.16	6.07	5.52	5.36	5.16	5.33
a 66	5.03	4.58	4.86	5.43	5.64	5.94	6.16	6.02	5.93	5.60	5.73	5.54	5.57
a 67	4.91	4.96	4.83	5.89	6.28	6.63	6.47	6.39	6.00	5.61	5.13	4.94	5.84
a 68	4.88	3.83	5.14	5.38	5.89	6.23	6.11	5.78	5.53	5.11	4.83	4.78	5.39
a 69	4.42	4.06	4.26	5.09	5.25	5.81	6.26	6.26	6.08	5.58	5.30	5.30	5.53
a1870	6.60	5.19	5.72	6.13	6.54	6.61	6.81	6.76	6.49	6.05	5.81	5.74	6.14
a 71	5.52	4.28	5.10	6.32	6.53	6.89	6.89	6.41	6.11	5.49	5.30	5.47	5.96
a 72	4.70	4.65	4.69	4.94	5.13	5.85	6.34	6.39	5.22	5.16	4.96	4.80	5.29
a 73	4.98	4.23	4.99	5.61	5.99	6.37	6.07	6.07	5.81	5.32	5.32	5.47	5.59
a 74	4.66	4.66	5.24	5.80	5.82	6.04	6.17	6.09	5.86	5.37	5.27	4.90	5.56
a 75	4.72	4.71	4.90	5.66	5.88	5.78	5.95	5.89	5.71	5.50	5.31	5.15	5.51
a 76	5.27	5.78	6.89	6.60	6.43	7.23	7.48	7.20	6.79	6.42	6.30	7.09	6.61
a 77	6.88	6.19	5.94	4.94	5.26	6.09	6.30	6.22	5.94	5.83	5.84	5.67	5.96
a 78	5.82	4.67	4.62	5.21	5.43	6.49	6.57	6.49	6.12	5.89	5.56	5.26	5.66
a 79	4.81	4.18	4.90	5.49	5.43	5.71	5.78	5.58	5.36	5.03	4.72	4.89	5.16
a1880	5.13	4.74	5.20	5.60	5.94	6.04	5.96	6.05	5.77	5.39	5.21	5.83	5.58
a 81	4.21	4.72	4.76	5.41	5.81	6.13	6.09	5.96	5.83	5.52	5.70	5.77	5.50
a 82	6.01	5.60	6.22	6.31	6.79	6.62	7.18	7.18	6.81	6.16	5.87	6.31	6.40
a 83	5.89	5.67	5.69	5.89	6.14	6.82	7.81	7.44	6.95	6.54	6.09	6.00	6.33
a 84	4.54	5.06	5.43	6.72	6.96	7.14	7.15	6.87	6.48	6.22	5.84	5.64	6.28
a 85	6.42	5.89	5.86	6.02	6.23	6.91	6.73	6.90	6.72	6.30	6.31	6.25	6.50
a 86	5.36	4.25	5.34	6.04	6.79	6.85	6.82	6.71	6.53	6.23	5.96	6.19	6.13
a 87	5.85	6.03	6.05	6.39	6.57	6.67	6.62	6.46	6.15	5.78	5.35	5.28	6.09
a 88	5.28	5.13	4.86	5.16	5.69	5.85	6.10	6.01	5.74	5.43	5.26	5.11	5.49
a 89	5.33	4.84	4.86	4.72	5.16	5.72	5.82	5.66	5.45	5.02	4.73	4.60	5.09
a1890	5.05	4.96	4.96	5.39	5.71	6.13	6.04	5.81	5.54	5.28	5.24	5.05	5.42
a 91	4.88	4.74	4.46	4.97	4.98	5.10	5.12	5.08	4.87	4.61	4.28	4.28	4.75
a 92	3.87	3.18	3.40	4.27	4.87	5.20	5.09	5.49	5.35	4.86	4.48	4.18	4.49
a 93	3.31	3.47	4.34	4.81	5.26	5.48	5.48	5.46	5.17	4.87	4.68	4.63	4.76
a 94	4.69	4.16	4.56	4.73	5.26	5.50	5.50	5.31	5.13	4.82	4.56	4.44	4.89
a 95	4.69	4.96	4.39	3.98	4.39	4.44	4.46	4.43	4.26	3.94	3.84	3.78	4.27
a 96	3.78	3.60	3.27	3.53	4.14	4.51	4.64	4.51	4.46	4.23	3.92	3.77	4.03
97	4.38	4.64	4.57	4.75	5.30	5.11	5.22	5.15	4.93	4.68	4.47	4.39	4.77
98	4.30	a 3.77	4.75	5.01	5.11	5.26	5.30	5.10	4.90	4.64	4.53	4.68	4.78
99	4.46	4.57	3.99	4.32	4.86	5.15	5.30	5.22	4.93	4.65	4.49	4.10	4.69
1900	4.02	4.24	4.07	4.44	4.79	4.99	5.01	5.06	4.89	4.74	4.53	4.41	4.67
01	4.01	3.98	3.93	3.99	3.94	4.61	5.06	5.07	4.89	4.86	4.90	4.67	4.48
02	3.31	2.84	3.96	4.22	a 4.80	a 4.86	5.50	5.41	5.08	4.92	4.62	4.64	4.48
03	4.09	4.40	4.75	5.31	5.27	5.38	5.44	5.36	5.29	5.04	4.84	4.94	5.05
04	3.76	3.23	4.02	5.04	5.01	5.02	5.07	5.02	5.00	5.01	4.94	4.90	4.79
05	3.78	3.80	3.97	4.73	5.11	5.09	5.00	5.74	5.52	5.18	4.84	4.73	4.87
06	4.86	3.99	4.00	4.88	5.30	5.43	5.38	5.54	5.30	5.09	4.90	4.80	4.99
07	4.94	4.46	4.90	5.24	5.44	5.75	5.90	5.76	5.51	5.40	5.06	4.96	5.27
Mean	574.91	574.53	574.97	575.38	575.69	575.98	576.05	575.97	575.71	575.43	575.10	575.17	575.46

Authority, U. S Lake Survey, except for supplied values.

a.—Supplied by applying to the St. Clair Flats readings, the mean monthly fall from St. Clair Flats to Windmill Point, as deduced from observations taken between the years 1897 and 1907, inclusive.

Note.—Elevations depend on P. B. M., 12, 584.22 ft., U. S. Lake Survey, 1903 Levels.

TABLE 9.

WATER LEVELS OF DETROIT RIVER.

Monthly mean elevations of water surface of Detroit River, at Amherstburg, Ont., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	573.48	573.12	573.84	574.19	574.40	574.48	574.20	574.06	573.66	573.37	573.15	573.11	573.74
a 61	2.83	2.55	3.01	4.00	4.52	4.56	4.34	4.42	4.18	3.94	3.70	3.68	3.82
a 62	3.65	3.36	3.62	4.37	4.70	4.66	4.67	4.33	3.96	3.57	3.10	3.28	3.93
a 63	3.68	3.97	3.93	4.00	4.27	4.12	4.01	3.97	3.82	3.97	3.83	3.62	3.84
a 64	3.31	2.46	2.98	3.14	3.93	3.87	3.62	3.39	3.11	2.70	2.40	2.68	3.04
a 65	2.23	1.65	1.99	2.66	3.33	3.30	3.27	3.23	3.13	2.82	2.31	2.29	2.68
a 66	2.00	1.84	2.25	2.78	3.09	3.34	3.46	3.35	3.13	2.11	2.74	2.87	2.82
a 67	2.56	2.34	2.66	2.93	3.54	3.84	3.66	3.39	2.94	2.80	1.96	1.86	2.85
a 68	1.64	1.26	1.57	2.65	3.19	3.57	3.55	3.07	2.74	2.28	1.90	1.90	2.48
a 69	1.87	1.80	2.30	2.85	3.19	3.67	3.66	3.80	3.47	2.91	2.42	2.89	2.89
a1870	2.11	2.34	2.13	2.73	4.03	3.90	4.05	4.03	3.72	3.33	2.90	2.90	3.32
a 71	2.67	2.34	2.81	3.24	3.80	3.62	3.61	3.44	3.31	2.53	2.22	1.90	2.93
a 72	1.80	1.56	1.49	1.64	2.17	2.53	2.53	2.54	2.35	2.07	1.61	1.50	1.97
a 73	1.38	1.39	1.48	2.71	3.47	3.54	3.53	3.51	3.05	2.74	2.41	2.90	2.66
a 74	3.27	3.32	3.37	3.49	3.67	3.73	3.77	3.65	3.13	2.68	2.13	2.04	3.19
a 75	1.79	1.63	1.78	2.13	2.69	3.11	3.26	3.26	3.05	2.58	2.20	2.64	2.53
a 76	2.58	3.14	3.31	4.26	4.69	4.79	4.69	4.42	4.20	3.96	3.61	3.39	3.94
a 77	2.97	2.61	2.60	2.96	3.33	3.39	3.64	3.54	3.40	2.96	2.78	2.68	3.12
a 78	3.04	3.18	3.33	3.70	4.03	4.03	4.03	3.85	3.66	3.30	2.97	3.17	3.52
a 79	2.73	2.39	2.64	2.95	3.19	3.27	3.31	3.13	2.74	2.50	1.90	2.38	2.77
a1880	2.76	2.80	2.96	3.07	3.43	3.53	3.65	3.43	3.14	2.90	2.48	2.26	3.02
a 81	1.83	1.94	2.28	2.93	3.42	3.65	3.61	3.33	2.92	2.86	2.55	2.68	2.83
a 82	3.33	3.33	3.50	3.97	4.36	4.40	4.34	4.24	3.91	3.45	3.00	2.61	3.73
a 83	2.50	2.71	2.92	3.99	3.54	4.28	4.44	4.42	4.05	3.72	3.21	3.38	3.51
a 84	3.01	3.27	3.48	3.96	4.34	4.41	4.30	4.08	3.89	3.33	2.94	2.89	3.58
a 85	2.49	2.28	2.16	2.98	3.75	4.26	4.22	4.27	4.06	3.68	3.70	3.77	3.49
a 86	3.77	3.04	2.87	3.70	4.09	4.18	4.17	4.01	3.70	3.46	3.04	3.07	3.59
a 87	2.83	3.26	4.06	4.06	4.33	4.34	4.13	3.84	3.53	2.95	2.55	2.68	3.55
a 88	2.49	2.22	2.34	2.92	3.36	3.38	3.54	3.48	3.06	2.60	2.53	2.51	2.94
a 89	2.53	2.37	2.39	2.53	2.80	3.23	3.43	3.16	2.71	2.28	1.86	2.26	2.62
a1890	2.60	2.80	3.05	3.47	3.90	4.26	3.89	3.47	3.24	3.04	2.80	2.77	3.29
a 91	2.53	2.51	2.99	2.81	2.72	2.68	2.76	2.62	2.39	1.90	1.39	1.52	2.40
a 92	1.53	1.32	1.36	1.96	2.76	3.51	3.66	3.35	2.97	2.40	1.94	1.75	2.38
a 93	1.39	1.47	1.71	2.39	2.53	2.80	3.28	2.98	2.49	2.13	1.90	1.90	2.22
a 94	2.06	1.94	1.99	2.34	2.82	3.03	3.01	2.66	2.45	2.13	1.78	1.80	2.33
a 95	1.45	1.23	1.25	1.45	1.76	1.84	1.74	1.70	1.54	1.05	0.82	1.10	1.41
a 96	1.16	1.10	1.07	1.47	1.94	2.20	2.09	2.24	1.93	1.71	1.21	1.38	1.64
a 97	1.31	1.51	1.90	2.40	2.83	2.91	2.91	2.79	2.45	1.98	1.69	1.78	2.20
a 98	1.81	2.01	2.29	2.82	3.06	3.08	2.87	2.71	2.27	2.06	1.81	1.78	2.38
99	a 1.88	a 1.86	a 2.07	a 2.23	a 2.72	a 2.82	b 2.76	b 2.80	b 2.14	b 1.96	b 1.85	b 1.40	2.19
1900	1.60	1.80	2.19	2.44	2.85	2.75	2.85	2.86	2.30	2.03	1.55	1.80	2.10
01	1.62	1.19	1.12	1.39	1.56	2.05	2.20	2.14	2.08	1.89	1.19	1.83	1.64
02	1.90	0.88	1.13	1.62	2.09	2.32	2.99	3.00	2.84	2.50	2.20	1.98	2.05
03	1.81	1.81	2.44	2.30	2.84	3.23	3.15	2.99	2.52	2.22	1.84	1.67	2.50
04	1.66	1.61	2.20	2.38	2.80	2.78	2.96	2.98	3.06	2.75	2.24	2.05	2.70
05	1.73	1.45	1.85	2.08	2.75	2.82	2.80	3.18	2.90	2.48	2.09	2.08	2.39
06	2.10	2.14	2.00	2.43	2.96	2.98	3.02	2.97	2.70	2.53	2.13	2.48	2.51
07	b 2.91	b 2.66	b 2.47	b 2.94	b 3.17	b 3.63	c 3.89	c 3.35	c 3.01	c 2.94	c 2.53	c 2.41	2.97
Mean	573.33	573.25	573.46	573.91	573.33	573.53	573.50	573.36	573.06	572.70	573.33	573.37	573.34

Authority, U. S. Lake Survey, except for supplied values.

c.—Supplied by applying to the Cleveland, O., readings, the mean monthly fall between Cleveland and Amherstburg, as deduced from observations taken during the period from July, 1900, to December, 1904, inclusive.

b.—Self-registering gage.

Note.—Elevations depend on Gage B. M., 579.327 ft., U. S. Lake Survey, 1903 Levels.

TABLE 10.

WATER LEVELS OF LAKE ERIE.

Monthly mean elevations of water surface of Lake Erie, at Cleveland, O., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	573.26	572.90	573.30	574.00	574.21	574.18	573.92	573.76	573.42	573.12	573.03	572.87	573.30
61	2.61	2.33	2.77	3.81	4.34	4.31	4.06	4.10	3.92	3.69	3.67	3.44	3.86
62	3.43	3.14	3.38	4.18	4.42	4.42	4.39	4.01	3.70	3.33	2.98	3.01	3.69
63	3.46	3.75	3.89	3.81	3.99	3.85	3.73	3.65	3.26	2.83	2.41	2.38	3.40
64	2.09	2.24	2.45	2.95	3.05	3.00	3.34	3.07	2.85	2.84	2.37	2.44	2.80
65	2.01	1.43	1.75	2.47	2.05	2.03	2.99	2.91	2.87	2.57	2.19	2.05	2.41
66	1.78	1.42	2.01	2.89	2.81	2.07	3.16	2.93	2.87	2.86	2.83	2.62	2.53
67	2.34	2.02	2.42	2.74	3.36	3.57	3.38	3.07	3.05	3.34	1.84	1.63	2.81
68	1.42	1.04	1.95	2.46	2.91	3.30	3.27	2.75	2.48	2.03	1.57	1.66	2.78
69	1.65	1.58	2.06	2.86	2.91	3.30	3.58	3.43	3.21	2.78	2.30	2.65	2.62
1870	2.80	3.12	2.89	3.54	3.75	3.72	3.76	3.71	3.46	3.06	2.73	2.66	3.29
71	2.45	2.12	2.57	3.05	3.32	3.35	3.33	3.13	2.95	2.33	2.10	1.66	2.69
72	1.58	1.34	1.25	1.45	1.89	2.26	2.25	2.22	1.99	1.83	1.49	1.26	1.73
73	1.16	1.17	1.34	2.52	3.10	3.27	3.25	3.19	2.79	2.49	2.29	2.66	2.44
74	3.05	3.10	3.13	3.30	3.39	3.46	3.49	3.33	2.87	2.43	2.01	1.80	2.96
75	1.57	1.40	1.34	1.94	2.41	2.84	2.97	2.96	2.83	2.33	2.19	2.40	2.26
76	2.34	2.92	3.57	4.09	4.41	4.53	4.41	4.11	3.94	3.41	3.49	3.15	3.79
77	2.75	2.89	2.96	2.79	3.04	3.12	3.26	3.32	3.14	2.74	2.93	2.74	2.98
78	2.83	2.96	3.09	3.61	3.75	3.75	3.75	3.53	3.40	3.05	2.85	2.95	3.23
79	2.51	2.37	2.40	2.75	2.91	3.00	3.03	2.81	2.48	2.22	1.78	2.04	2.52
1880	2.84	2.88	2.72	2.88	3.18	3.26	3.33	3.11	2.86	2.44	2.20	2.02	2.77
81	1.61	1.72	2.04	2.74	3.14	3.38	3.32	3.01	2.66	2.61	2.43	2.64	2.63
82	3.11	3.11	3.86	3.78	3.98	4.13	4.00	3.92	3.65	3.20	3.85	2.37	3.69
83	2.26	2.49	2.95	2.80	3.26	3.96	4.16	4.10	3.79	3.47	3.09	3.13	3.37
84	2.79	3.05	3.34	3.79	4.06	4.14	3.92	3.76	3.33	3.00	2.62	2.45	3.34
85	2.27	2.06	1.92	2.74	3.47	3.98	3.94	3.95	3.80	3.70	3.58	3.58	3.24
86	3.85	3.82	3.93	3.81	3.81	3.91	3.89	3.99	3.44	3.21	2.92	2.83	3.53
87	2.61	3.04	3.83	3.87	4.06	4.07	3.84	3.83	3.29	2.76	2.43	2.45	3.31
88	2.27	2.00	2.10	2.73	2.98	3.11	3.26	3.16	2.73	2.35	2.41	2.39	2.69
89	3.31	3.15	1.96	2.34	2.83	3.00	3.15	2.84	2.45	2.03	1.76	2.02	2.58
1890	2.26	2.47	2.79	3.28	3.62	3.89	3.61	3.15	2.96	2.70	2.76	2.33	3.00
91	3.21	3.29	2.75	2.62	2.44	2.53	2.43	2.21	2.03	1.65	1.21	1.26	2.15
92	1.31	1.10	1.14	1.70	2.50	3.26	3.36	3.08	2.71	2.15	1.82	1.55	2.14
93	1.17	1.25	1.47	2.30	3.04	3.23	3.26	3.01	2.23	1.82	1.48	1.56	2.09
94	1.84	1.72	1.73	2.15	2.84	2.75	2.72	2.36	2.19	1.87	1.63	1.66	2.09
95	1.23	1.00	1.01	1.30	1.48	1.67	1.46	1.36	1.26	0.80	0.70	0.86	1.17
96	0.69	0.95	0.83	1.23	1.66	1.93	1.81	2.02	1.70	1.46	1.09	1.12	1.40
97	1.09	1.29	1.66	2.21	2.84	2.64	2.63	2.47	2.19	1.70	1.57	1.54	1.96
98	1.89	1.79	2.03	2.63	2.75	2.61	2.59	2.39	2.01	1.81	1.69	1.59	2.14
99	1.67	1.46	1.83	2.13	2.44	2.84	2.36	2.06	1.85	1.61	1.62	1.34	1.91
1900	1.38	1.87	1.92	2.22	2.39	2.47	2.34	2.31	1.99	1.75	1.49	1.45	1.96
01	1.36	1.00	0.88	1.39	1.31	1.73	1.91	1.78	1.71	1.33	1.16	1.19	1.39
02	1.03	0.62	0.94	1.49	1.86	2.12	2.74	2.73	2.38	2.29	2.02	1.83	1.86
03	1.72	1.70	2.38	3.05	3.09	3.05	2.98	2.76	2.50	2.25	1.77	1.91	2.39
04	1.19	1.28	1.86	2.91	3.17	3.32	3.41	3.10	2.84	2.49	2.12	1.77	2.44
05	1.52	1.31	1.18	1.83	2.46	2.98	3.05	2.87	2.63	2.31	1.93	1.92	2.17
06	1.94	1.98	1.71	2.13	2.40	2.90	2.64	2.63	2.35	2.21	2.18	2.43	2.25
07	2.76	2.48	2.34	2.71	2.95	3.27	3.31	3.06	2.77	2.89	2.41	2.26	2.75
Mean	573.10	573.08	573.22	573.70	573.93	573.94	573.92	573.84	573.78	573.45	573.21	573.14	573.60

Authority, U. S. Lake Survey.

From January, 1860, to December, 1903, inclusive, data from U. S. Lake Survey Report for 1901, page 4097.

Readings from 1904 to 1907, inclusive, from U. S. Lake Survey Annual Reports.

Note.—Elevations depend on B. M. "I" 581.41 ft., U. S. Lake Survey, 1903 Levels.

TABLE 11.

WATER LEVELS OF LAKE ERIE.

Monthly mean elevations of water surface of Lake Erie, at Buffalo Breakwater Light-house, in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a1860	573.51	573.03	573.28	573.91	574.11	574.15	573.96	573.72	573.44	573.20	573.22	573.35	573.56
a 61	2.86	2.36	2.75	3.73	4.14	4.26	4.10	4.06	3.94	3.77	3.86	3.62	3.64
a 62	3.66	3.17	3.20	4.00	4.23	4.39	4.43	3.97	3.73	3.40	3.17	3.39	3.75
a 63	3.71	3.78	3.67	3.73	3.89	3.82	3.77	3.61	3.26	2.90	2.90	2.76	3.46
a 64	2.34	2.27	2.43	2.84	3.55	3.57	3.38	3.06	2.87	2.63	2.56	2.53	2.86
a 65	2.26	1.46	1.73	2.38	2.95	3.00	3.00	2.67	2.89	2.65	2.38	2.48	2.50
a 66	2.03	1.65	1.99	2.50	2.71	3.04	3.22	2.89	2.89	2.94	2.81	3.01	2.64
a 67	2.59	2.05	2.40	2.65	3.16	3.54	3.43	3.03	2.70	2.42	2.03	2.00	2.67
a 68	1.67	1.07	1.61	2.37	2.81	3.27	3.31	2.71	2.50	2.11	2.06	2.06	2.39
a 69	1.90	1.61	2.04	2.27	2.81	3.27	3.63	3.44	3.23	2.84	2.49	2.08	2.71
a1870	3.14	3.15	2.87	3.45	3.46	3.69	3.80	3.67	3.43	3.16	2.97	3.04	3.34
a 71	2.70	2.15	2.53	2.96	3.23	3.32	3.37	3.06	2.97	2.86	2.39	2.04	2.75
a 72	1.83	1.37	1.23	1.38	1.79	2.23	2.29	2.13	2.01	1.90	1.69	1.84	1.79
a 73	1.41	1.20	1.22	2.43	3.09	3.24	3.29	3.15	2.81	2.57	2.43	2.04	2.49
a 74	3.30	3.13	3.11	3.21	3.30	3.43	3.53	3.29	2.89	2.51	2.20	2.13	3.01
a 75	1.82	1.43	1.52	1.85	2.21	2.81	3.01	2.93	2.84	2.41	2.37	2.78	2.34
a 76	2.61	2.95	2.55	4.00	4.31	4.49	4.45	4.07	3.96	3.49	3.05	2.53	3.76
a 77	3.00	2.62	2.34	3.70	3.94	3.09	3.40	3.18	3.16	2.83	2.65	2.12	2.94
a 78	3.07	2.99	3.07	3.43	3.65	3.72	3.79	3.49	3.42	3.13	3.04	3.21	3.34
a 79	2.76	2.40	2.38	2.67	2.81	2.97	3.07	2.77	2.80	2.33	1.97	2.42	2.59
a1880	2.79	2.61	2.70	2.79	3.05	3.23	3.29	3.07	2.90	2.53	2.55	2.40	2.82
a 81	1.86	1.75	2.02	2.65	3.04	3.25	3.37	2.97	2.68	2.60	2.62	2.02	2.67
a 82	3.39	3.14	3.54	3.66	3.85	4.10	4.10	3.86	3.67	3.28	3.07	2.75	3.64
a 83	3.33	3.32	2.66	3.71	3.18	3.98	4.20	4.06	3.61	3.56	3.28	3.50	3.33
a 84	3.04	3.05	3.22	3.70	3.96	4.11	3.96	3.72	3.35	3.08	2.71	2.53	3.40
a 85	2.83	2.09	1.90	2.65	3.37	3.95	3.96	3.91	3.82	3.78	3.77	3.91	3.30
a 86	3.80	2.83	2.61	2.42	2.71	2.89	2.93	3.06	2.46	2.29	2.11	2.21	2.61
87	e 2.86	e 3.07	2.75	2.71	2.98	4.07	3.91	3.81	3.20	3.26	2.71	2.89	3.41
b 88	2.57	1.96	2.09	2.09	2.24	3.01	3.22	3.13	2.78	2.89	2.44	2.74	2.67
b 89	2.56	2.24	1.86	2.23	2.69	2.96	3.00	2.91	2.53	2.03	2.03	2.36	2.48
b1890	2.93	2.74	2.96	2.21	2.89	2.92	2.84	3.17	2.83	2.81	3.00	2.74	2.13
b 91	2.48	2.36	2.50	2.62	2.40	2.33	2.56	3.27	2.10	1.73	1.67	1.70	2.22
b 92	1.61	0.93	1.13	1.96	2.40	2.21	2.42	3.05	2.73	2.45	2.07	2.04	2.35
b 93	1.27	1.23	1.53	2.19	2.91	2.96	2.13	2.54	2.39	2.19	2.17	2.12	2.24
b 94	2.13	1.75	1.86	2.05	2.85	2.94	2.81	2.34	2.17	2.17	1.96	1.82	2.22
b 95	1.69	1.00	0.93	1.13	1.46	1.86	1.86	1.42	1.44	1.20	0.71	0.97	1.28
b 96	1.13	1.05	0.90	1.32	1.67	1.98	1.96	2.09	1.67	1.41	1.44	1.32	1.43
b 97	1.69	1.15	1.08	2.16	2.60	2.89	2.97	3.45	2.99	1.66	1.69	1.81	2.00
b 98	1.69	1.57	1.95	2.55	2.98	2.73	2.50	2.48	2.08	1.91	2.01	2.07	2.16
99	2.08	1.89	c 1.85	c 2.04	c 2.23	c 2.51	c 2.45	c 2.09	c 1.90	c 1.48	c 1.35	c 1.96	1.96
a1900	1.67	1.61	1.83	2.16	2.83	2.41	2.43	2.21	2.07	1.68	1.64	1.77	2.01
c 01	c 1.00	c 1.03	0.62	1.05	1.17	1.99	1.85	1.70	1.75	1.53	1.39	1.37	1.42
c 02	1.41	0.79	0.95	1.40	1.74	2.05	2.73	2.64	2.20	2.28	2.16	c 2.20	1.99
c 03	1.99	1.70	2.13	2.83	2.85	2.96	2.99	2.84	2.35	2.24	2.01	2.02	2.43
c 04	1.06	1.20	1.86	2.89	3.23	3.49	3.41	3.12	2.84	2.61	2.31	2.13	2.59
c 05	1.74	1.35	1.13	1.79	2.38	2.87	2.93	2.68	2.68	2.56	2.20	2.45	2.24
c 06	2.28	1.88	1.66	2.06	2.27	2.49	2.65	2.51	2.37	2.25	2.23	2.45	2.25
c 07	2.96	2.47	2.22	2.62	2.94	3.13	2.83	2.62	2.30	2.70	2.71	2.68	2.80
Mean	573.36	573.08	573.19	573.94	573.97	573.31	573.36	573.02	573.80	573.56	573.43	573.52	573.57

Authority, U. S. Lake Survey, except for supplied values.

a.—Supplied by applying to the Cleveland, O., readings, the mean monthly rise or fall between Cleveland, O., and Buffalo, N. Y., from June, 1869, to December, 1906, inclusive.

b.—Derived from U. S. Lake Survey tables by subtracting 0.1 foot from records there given.

c.—Self-registering gage.

Note.—Elevations depend on B. M. "Light-house," 580.101 ft., U. S. Lake Survey, 1903 Levels.

TABLE 12.

WATER LEVELS OF LAKE ONTARIO.

Monthly mean elevations of water surface of Lake Ontario, at Charlotte, N. Y., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	246.88	246.41	246.52	246.64	246.78	246.97	247.09	247.06	246.97	246.61	246.49	246.50	246.67
61	6.26	6.29	6.72	7.27	8.04	8.26	8.26	8.00	7.84	7.09	7.09	7.40	7.46
62	7.06	6.73	6.89	7.73	8.56	8.43	8.32	7.98	7.46	6.98	6.88	6.45	7.44
63	6.53	6.71	6.83	7.47	7.97	7.97	7.73	7.43	6.97	6.44	6.25	6.23	7.06
64	6.10	6.06	6.15	6.99	7.74	8.07	7.67	7.39	6.78	6.47	6.36	6.78	6.99
65	6.51	6.17	6.86	7.21	7.47	7.44	7.24	6.75	6.29	6.04	5.72	5.84	6.59
66	5.45	5.32	5.52	5.98	6.84	7.03	6.85	6.63	6.49	6.27	6.29	6.81	6.29
67	6.79	6.77	6.90	7.31	8.10	8.40	8.05	8.09	7.80	7.35	5.86	5.34	7.31
68	5.16	4.80	5.16	5.83	6.36	6.70	6.87	6.26	6.13	5.43	5.84	5.83	5.91
69	5.82	5.51	5.70	6.44	7.00	7.20	7.47	7.43	7.27	6.97	6.86	6.71	6.78
1870	7.34	7.39	7.32	8.23	9.05	9.61	8.54	8.09	7.49	7.14	6.72	6.13	7.91
71	6.30	6.03	6.27	7.08	7.32	7.25	7.06	6.64	6.30	5.73	5.35	4.78	6.31
72	4.62	4.42	4.30	4.72	4.96	5.26	5.34	5.19	4.94	4.84	4.72	4.54	4.85
73	4.47	4.35	4.25	6.32	6.91	6.94	6.90	6.66	6.32	5.86	5.70	5.53	5.89
74	5.30	5.04	7.06	7.10	7.23	7.26	7.20	7.14	6.64	6.03	5.50	5.20	6.64
75	4.83	4.53	4.98	5.46	5.81	5.96	6.01	5.82	5.60	5.35	5.17	5.07	5.44
76	5.43	6.11	6.70	7.68	8.20	8.42	8.44	8.09	7.25	7.00	6.68	6.39	7.31
77	5.98	5.74	5.88	6.46	6.60	6.41	6.54	6.27	5.86	5.46	5.23	5.46	5.98
78	5.00	5.85	6.34	6.74	7.06	7.06	7.06	6.97	6.82	6.38	6.25	7.02	6.60
79	6.80	6.45	6.47	6.73	6.84	6.91	6.72	6.34	5.94	5.80	5.10	5.12	6.23
1880	5.34	5.05	5.06	6.23	6.96	6.83	6.65	6.16	5.88	5.27	5.27	5.07	5.85
81	4.70	4.66	4.43	5.79	6.06	6.06	6.23	6.00	5.58	5.24	5.24	5.25	5.51
82	5.74	5.94	6.51	6.83	7.06	7.09	7.09	7.23	6.83	6.35	6.06	6.06	6.60
83	6.23	6.20	6.60	6.16	6.79	7.26	7.35	7.70	7.28	6.84	6.69	6.49	6.80
84	6.44	6.35	7.25	8.03	8.16	8.05	7.91	7.66	7.15	6.75	6.23	6.09	7.23
85	6.03	5.76	5.84	6.26	7.07	7.40	7.35	7.26	7.17	6.97	7.00	7.13	6.79
86	7.35	7.56	7.68	8.04	8.09	8.24	7.95	7.80	7.00	6.72	6.43	6.36	7.39
87	6.15	6.84	7.27	7.84	8.08	8.07	7.78	7.29	6.90	6.31	5.73	5.27	6.93
88	5.45	5.28	5.48	5.96	6.22	6.24	6.18	6.01	5.78	5.48	5.31	5.20	5.73
89	5.20	5.09	5.76	5.98	6.12	6.02	6.76	6.59	5.97	5.46	5.25	5.25	5.79
1890	5.18	5.47	5.78	6.09	7.06	7.06	7.09	7.23	6.85	6.42	6.17	6.04	6.46
91	6.02	6.10	6.06	7.27	7.19	6.78	6.47	6.10	5.68	5.04	4.84	4.36	5.98
92	4.57	4.31	4.60	4.90	5.15	5.73	6.26	6.17	5.90	5.46	5.16	5.07	5.28
93	5.08	4.78	5.11	5.61	7.06	7.31	7.09	6.69	6.21	5.77	5.27	5.03	6.09
94	5.61	5.97	6.02	6.09	6.26	6.75	6.52	6.26	6.44	5.75	5.27	6.24	6.13
95	4.86	4.80	4.40	4.74	4.96	4.70	4.52	4.26	4.34	3.94	3.41	3.51	4.27
96	3.77	4.06	4.36	5.15	5.44	5.23	5.12	4.89	4.51	4.28	4.08	3.96	4.57
97	3.94	3.86	4.30	4.94	5.32	5.49	5.49	5.03	5.17	4.68	4.39	4.47	4.82
98	4.70	5.00	5.46	5.90	6.12	5.76	5.56	5.47	5.11	4.85	4.75	4.74	5.18
99	4.80	4.75	5.07	5.51	6.01	6.15	5.95	5.56	5.04	4.71	4.59	4.59	5.19
1900	4.82	4.64	5.06	5.27	6.02	6.09	6.06	5.51	5.17	4.85	4.62	4.57	5.24
01	4.82	4.75	4.80	5.51	5.95	6.07	5.99	5.53	5.31	4.76	4.53	4.55	5.18
02	4.62	4.67	5.05	5.96	6.45	6.67	6.60	6.22	5.81	5.54	5.19	4.96	5.70
03	4.96	5.09	5.66	6.06	6.99	6.99	6.96	6.43	6.09	5.80	5.44	5.26	5.99
a 04	4.87	5.06	5.66	6.06	7.06	7.06	6.96	7.79	7.27	6.96	6.33	6.06	6.61
a 05	5.93	5.89	6.35	6.19	6.33	6.74	7.10	7.08	6.71	6.27	6.03	6.06	6.41
06	a 6.24	a 6.34	a 6.14	a 6.33	a 6.81	a 6.90	a 6.75	a 6.45	a 6.06	5.84	5.79	5.91	6.26
07	6.43	6.68	6.62	6.96	7.31	7.27	7.80	7.08	6.60	6.24			
Mean	265.61	265.69	265.85	266.44	266.84	266.96	266.93	266.96	266.76	266.43	266.23	265.86	266.36

Authority, U. S. Lake Survey.

a.—From self-registering gage.

Note.—Elevations depend on B. M. "I," 263.186 ft., U. S. Lake Survey, 1903 Levels.

TABLE 13.

WATER LEVELS OF LAKE ONTARIO.

Monthly mean elevations of water surface of Lake Ontario, at Oswego, N. Y., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	246.58	246.72	246.77	246.80	247.03	247.57	247.82	247.26	246.86	246.67	246.73	246.73	246.96
61	6.44	6.56	7.01	7.23	8.18	8.54	8.32	8.07	7.80	7.81	7.82	7.61	7.80
62	7.11	6.69	7.18	8.06	8.88	8.63	8.72	8.26	7.61	7.08	6.73	6.62	7.63
63	6.77	6.83	6.91	7.83	8.03	8.18	7.77	7.31	6.93	6.74	6.56	6.57	7.19
64	6.33	6.17	6.26	6.83	7.82	8.13	7.80	7.34	6.81	6.58	6.55	6.65	6.94
65	7.08	7.23	7.38	7.46	7.62	7.86	7.51	6.90	6.39	6.07	5.82	5.96	6.80
66	5.46	5.47	5.48	5.94	6.02	5.92	6.84	6.74	6.65	6.52	6.28	6.20	6.13
67	5.96	5.92	6.02	7.52	8.21	8.46	8.11	7.48	6.98	6.33	5.59	4.83	6.84
68	4.51	4.91	4.88	5.33	6.13	6.54	6.42	6.13	5.94	5.35	5.20	5.37	5.55
69	5.23	5.34	5.56	6.00	6.73	6.97	7.20	7.35	7.17	7.06	6.68	6.85	6.52
1870	7.38	7.41	7.41	7.35	8.06	8.63	8.31	7.97	7.38	6.96	6.38	6.13	7.59
71	6.06	5.89	6.10	6.70	7.12	7.06	6.90	6.46	6.13	5.63	5.31	4.90	6.18
72	4.73	4.51	4.35	4.84	4.96	5.29	5.35	5.19	4.90	4.74	4.69	4.33	4.83
73	4.31	4.35	4.50	6.46	7.00	6.92	6.88	6.60	6.18	5.78	5.80	5.79	5.96
74	6.33	6.75	7.30	7.19	7.17	7.26	7.31	6.96	6.34	5.94	5.37	5.06	6.57
75	4.73	4.35	4.64	5.44	5.71	5.87	5.90	5.76	5.55	5.27	5.08	4.90	5.27
76	5.31	5.97	6.52	7.50	8.06	8.30	8.37	7.91	7.30	6.96	6.60	6.42	7.10
77	5.99	5.82	5.77	6.46	6.83	6.43	6.47	6.20	5.77	5.34	5.25	5.35	5.98
78	5.48	5.98	6.39	6.94	6.98	6.97	6.93	6.53	6.39	6.23	6.21	7.03	6.51
79	6.81	6.45	6.30	6.71	6.80	6.83	6.67	6.32	5.90	5.46	5.07	5.10	6.20
1880	5.32	5.60	5.94	6.12	6.27	6.51	6.53	6.00	5.72	5.31	5.27	5.10	5.81
81	4.74	4.73	5.39	5.81	5.99	6.21	6.28	5.96	5.40	5.18	5.16	5.18	5.80
82	6.72	5.90	6.50	6.83	7.02	7.53	7.82	7.19	6.81	6.30	5.86	5.89	6.57
83	5.32	5.38	5.62	6.14	6.79	7.49	8.02	7.84	7.36	6.93	6.69	6.55	6.88
84	6.61	6.88	7.56	8.17	8.19	8.09	7.85	7.65	7.22	6.80	6.30	6.15	7.28
85	6.14	5.87	5.89	6.27	7.07	7.44	7.56	7.43	7.21	7.02	7.07	7.26	6.83
86	7.00	7.07	7.81	8.43	8.64	8.44	8.04	7.60	7.24	6.98	6.81	6.43	7.61
87	6.17	6.92	7.43	7.64	8.20	8.16	7.98	7.57	6.76	6.27	6.02	5.75	7.09
88	5.44	5.30	5.54	6.17	6.24	6.26	6.24	6.34	5.85	5.49	5.43	5.41	5.81
89	5.62	5.76	5.96	6.17	6.32	6.62	6.63	6.57	6.01	5.87	5.17	5.74	6.03
1890	6.25	6.60	6.95	7.17	7.53	8.16	7.99	7.32	6.97	6.64	6.72	6.81	7.07
91	6.19	6.45	6.90	7.47	7.25	6.83	6.55	6.11	5.68	5.04	4.44	4.41	6.12
92	4.51	4.48	4.61	5.19	5.25	5.61	6.33	6.36	6.04	5.80	5.33	5.20	5.38
93	4.87	4.76	5.34	5.99	7.15	7.37	7.11	6.57	6.30	5.78	5.37	5.22	5.98
94	5.56	5.74	6.04	6.09	6.27	6.80	6.60	6.02	5.51	5.26	4.93	4.88	5.78
95	4.49	4.43	4.33	4.86	5.00	4.88	4.89	4.54	4.00	3.86	3.41	3.44	4.29
96	3.80	4.26	4.49	5.41	5.43	5.23	6.08	4.94	4.48	4.23	3.97	3.97	4.62
97	3.88	3.82	4.32	4.96	5.40	5.61	5.61	5.00	5.10	4.47	4.41	4.47	4.80
98	4.64	5.08	5.48	5.92	6.08	6.13	5.85	5.50	5.09	4.84	4.80	4.90	5.37
99	4.96	4.86	5.13	5.69	5.94	6.07	5.93	5.46	e 4.95	e 4.56	e 4.42	e 4.36	5.20
e1900	4.43	4.85	5.19	5.80	5.99	5.91	5.82	5.54	5.13	4.72	4.55	4.54	5.23
e 01	4.68	4.42	4.39	5.03	5.91	5.99	5.74	5.43	5.10	4.68	4.38	4.26	5.06
e 02	4.42	4.30	4.95	5.40	5.47	5.53	5.97	6.11	5.68	5.42	5.05	4.89	5.27
e 03	4.93	5.16	5.75	6.44	6.56	6.44	6.39	6.25	6.07	5.72	5.36	5.11	5.87
04	4.73	5.00	5.63	7.00	7.61	7.87	7.79	7.64	7.25	6.87	6.38	5.81	6.84
05	5.79	5.49	5.39	6.13	6.35	6.89	6.96	6.90	6.75	6.45	6.07	5.88	6.21
06	6.13	6.09	5.91	6.25	6.36	6.41	6.37	6.26	5.81	5.49	5.58	5.74	6.03
07	6.34	6.48	6.47	6.85	7.08	7.11	7.13	6.90	6.50	6.46	6.33	6.33	6.66
Mean	245.18	245.55	245.91	246.49	246.83	246.96	246.93	246.63	246.22	245.88	245.63	245.57	246.19

Authority, U. S. Lake Survey.

e.—Self-registering gage.

Floods in Oswego River during the spring may cause abnormal gage readings from 0.2 to 0.3 foot above the true mean stage of Lake Ontario.

Note.—Elevations depend on zero of gage, 244.13 ft., and B. M. "A", 251.90 ft., U. S. Lake Survey, 1903 Levels.

TABLE 14.

WATER LEVELS OF ST. LAWRENCE RIVER.

Monthly mean elevation of water surface of St. Lawrence River, at Ogdensburg, N. Y., in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
a 1860	245.65	245.73	245.83	245.86	246.07	246.86	246.83	246.20	245.91	245.73	245.81	245.79	246.01
a 61	5.52	5.63	6.05	6.26	7.16	7.50	7.29	7.05	6.81	6.81	6.82	6.62	6.61
a 62	6.15	5.75	6.21	7.06	7.82	7.57	7.67	7.23	6.62	6.12	5.70	5.60	6.64
a 63	5.82	5.88	5.96	6.04	7.03	7.16	6.77	6.34	5.96	5.80	5.63	5.64	6.22
a 64	5.41	5.26	5.35	5.88	6.82	7.10	6.90	6.37	5.87	5.65	5.62	5.72	5.99
a 65	6.12	6.26	6.40	6.48	6.63	6.67	6.53	5.95	5.38	5.17	4.93	4.78	5.94
a 66	4.80	4.60	4.61	5.06	5.12	5.03	5.89	5.80	5.72	5.89	5.37	5.20	5.22
a 67	5.08	5.03	5.60	6.54	7.19	7.44	7.09	6.50	6.03	5.41	4.72	4.00	5.89
a 68	3.70	3.79	4.05	4.65	5.22	5.61	5.50	5.23	5.05	4.49	4.35	4.51	4.89
69	a 4.27	a 4.43	a 4.60	a 5.19	a 5.81	6.18	6.41	6.41	6.16	6.08	5.70	6.04	5.65
1870	6.32	6.36	6.18	7.35	7.87	7.60	7.30	7.03	6.19	5.87	5.64	a 5.23	6.56
71	a 5.16	a 5.00	a 5.20	a 5.76	6.03	6.26	6.01	5.66	5.34	4.99	4.39	a 4.07	5.32
72	a 3.91	a 3.70	a 3.55	a 4.01	4.31	4.53	4.77	4.66	4.59	4.09	a 3.87	a 3.55	4.13
73	a 3.51	a 3.53	a 3.60	a 5.44	6.15	6.18	6.20	a 5.67	a 5.27	a 4.85	a 4.73	a 4.90	5.07
74	a 5.43	a 5.81	a 6.33	a 6.32	a 6.21	a 6.20	a 6.24	6.16	a 5.42	a 5.06	a 4.51	a 4.19	5.66
a 75	3.91	3.88	3.82	4.57	4.82	4.98	5.01	4.86	4.65	4.41	4.24	4.07	4.43
a 76	4.46	5.07	5.59	6.53	7.06	7.27	7.24	6.90	6.33	6.01	5.67	5.50	6.14
a 77	5.00	4.74	4.89	5.54	5.60	5.51	5.55	5.29	4.89	4.48	4.40	4.52	5.08
a 78	4.61	4.51	5.47	5.71	6.03	6.02	5.96	5.90	5.66	5.41	5.30	6.06	5.65
a 79	5.87	5.53	5.39	5.77	5.86	5.88	5.73	5.40	5.01	4.59	4.23	4.25	5.29
a 1880	4.46	4.73	5.05	5.32	5.36	5.56	5.59	5.19	4.84	4.45	4.41	4.25	4.98
a 81	3.91	3.91	3.83	4.92	5.09	5.20	5.37	5.06	4.54	4.23	4.23	4.32	4.64
a 82	4.85	5.01	5.57	5.88	6.06	6.54	6.54	6.22	5.87	5.39	4.99	4.72	5.64
a 83	4.46	4.52	4.74	5.23	5.85	6.51	7.01	6.84	6.38	5.97	5.75	5.63	5.74
84	a 5.58	a 5.98	a 6.37	a 7.15	a 7.17	a 7.07	a 6.87	a 6.06	6.29	5.97	5.85	a 5.24	6.35
85	a 5.23	a 4.96	a 4.72	a 5.36	a 6.11	6.47	a 6.59	a 6.45	a 6.24	6.05	a 6.11	a 6.27	5.88
a 86	6.61	6.68	6.81	7.39	7.59	7.40	7.03	6.61	6.27	6.00	5.86	5.80	6.63
87	a 5.26	a 5.97	a 6.45	a 6.65	7.14	7.08	6.90	a 6.39	a 5.83	a 5.45	a 5.12	a 4.87	6.09
a 88	4.57	4.44	4.67	5.26	5.33	5.37	5.42	5.23	4.96	4.62	4.56	4.45	4.92
a 89	4.74	4.88	5.06	5.26	5.40	5.70	5.88	5.64	5.11	4.70	4.32	4.60	5.13
1890	a 5.34	a 5.67	a 5.96	a 6.21	6.89	7.00	6.97	6.13	a 6.02	a 5.71	a 5.78	a 5.58	6.06
91	a 5.28	a 5.53	a 6.04	a 6.49	a 6.26	5.73	5.49	5.07	4.71	4.20	3.99	a 3.80	5.21
92	a 3.70	a 3.67	a 3.79	a 4.34	a 4.40	a 4.02	5.36	5.15	5.21	4.67	4.36	a 4.25	4.43
a 93	4.04	3.93	4.20	5.09	6.19	6.39	6.15	5.64	5.39	4.90	4.51	4.27	5.08
a 94	4.69	4.96	5.14	5.19	5.36	5.88	5.67	5.13	4.64	4.40	4.08	3.76	4.99
a 95	3.68	3.69	3.82	4.06	4.16	4.06	3.77	3.54	3.22	2.90	2.66	2.60	3.40
a 96	3.08	3.46	3.66	4.55	4.57	4.49	4.34	4.10	3.68	3.43	3.19	3.12	3.89
a 97	3.10	3.05	3.32	4.12	4.54	4.73	4.72	4.73	4.36	3.88	3.60	3.55	3.97
a 98	3.83	4.34	4.61	5.08	5.18	5.33	4.95	4.66	4.34	4.01	4.06	4.07	4.51
a 99	4.14	4.05	4.29	4.81	5.08	5.17	5.08	4.80	4.11	3.74	3.61	3.59	4.34
1900	a 3.81	a 4.05	a 4.34	a 4.91	a 5.09	a 5.02	a 4.93	a 4.67	b 4.14	b 3.84	b 3.86	b 3.66	4.37
b 01	3.78	3.85	3.98	4.36	4.83	4.90	4.81	4.53	4.26	3.84	3.44	3.54	4.11
02	b 3.87	b 3.87	b 4.14	b 4.67	b 4.62	b 4.71	b 5.06	b 5.13	b 4.80	b 4.51	b 4.21	a 4.00	4.42
b 03	3.97	4.00	4.06	5.45	5.60	5.43	5.47	5.34	5.13	4.79	4.47	4.34	4.96
04	a 3.90	b 4.04	b 4.47	b 5.50	b 6.45	b 6.75	b 6.63	b 6.54	b 6.23	b 5.90	b 5.30	b 4.81	5.60
a 05	4.91	4.83	4.24	5.00	5.23	5.67	5.96	5.65	5.70	5.43	5.34	5.03	5.35
a 06	5.30	5.11	4.95	5.21	5.33	5.42	5.36	5.21	4.93	4.66	4.62	4.64	5.09
a 07	5.30	5.43	5.32	5.74	6.03	6.05	6.12	5.90	5.51	5.43	5.31	5.24	5.61
Mean	244.70	244.75	244.99	245.54	245.86	246.00	245.96	245.69	245.23	244.90	244.76	244.69	245.37

Authority, U. S. Lake Survey, except for supplied values.

a.—Supplied from Oswego, N. Y., readings by formula (Ogdensburg—340) = 0.9426 (Oswego—340)—0.553.

b.—Self-registering gage.

Note.—Elevations depend on zero of gage, 244.87 ft. and B. M. "O," 247.126 ft., U. S. Lake Survey, 1901 Levels.

TABLE 15.

WATER LEVELS OF ST. LAWRENCE RIVER.

Monthly mean elevations of water surface of St. Lawrence River, at Lock No. 27, Galop Canal, head of Galop Rapids, in feet above mean tide at New York.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	244.08	244.22	244.26	244.29	244.80	245.31	245.55	245.02	244.64	244.46	244.54	244.22	244.62
61	3.95	4.07	4.49	4.70	5.89	6.23	6.02	5.79	5.34	5.54	5.55	5.06	5.22
62	4.59	4.19	4.65	5.50	6.55	6.31	6.40	5.97	5.35	4.85	4.53	4.13	5.25
63	4.26	4.32	4.40	5.08	5.75	5.89	5.50	5.07	4.71	4.52	4.36	4.06	4.83
64	3.85	3.70	3.78	4.32	5.55	5.83	5.53	5.10	4.80	4.38	4.35	4.15	4.60
65	4.56	4.70	4.84	4.92	5.36	5.40	5.26	4.88	4.10	3.90	3.66	3.21	4.55
66	3.08	3.04	3.04	3.50	3.85	3.75	4.62	4.53	4.44	4.32	4.09	3.73	3.83
67	3.49	3.46	4.12	4.97	5.92	6.17	5.82	5.23	4.76	4.14	3.44	2.43	4.50
68	2.93	2.22	2.48	3.08	3.94	4.34	4.22	3.95	3.77	3.21	3.07	2.94	3.35
69	2.80	2.91	3.12	3.63	4.54	4.75	5.05	5.11	4.94	4.85	4.47	4.34	4.21
1870	4.73	4.87	4.87	5.78	6.63	6.32	6.01	5.60	5.04	4.73	4.19	3.66	5.21
71	3.50	3.43	3.62	4.20	4.89	4.83	4.66	4.38	3.94	3.47	3.08	2.50	3.88
72	2.34	2.13	1.96	2.44	2.85	3.16	3.21	3.06	2.79	2.64	2.50	1.98	2.60
73	1.94	2.00	2.12	2.97	4.77	4.70	4.66	4.40	4.00	3.57	3.45	3.34	3.58
74	3.37	4.24	4.77	4.66	4.94	5.02	4.97	4.76	4.13	3.77	3.23	2.62	4.26
75	1.45	0.46	1.77	3.24	3.61	3.80	3.79	3.63	3.53	3.15	2.81	2.77	2.83
76	2.91	2.73	4.02	5.35	5.95	b 5.23	6.25	5.64	4.99	4.02	4.20	3.67	4.82
77	2.37	2.17	2.57	3.80	4.81	4.38	4.56	4.05	3.81	2.90	3.00	2.99	3.57
78	2.97	3.20	4.01	4.63	5.20	b 4.74	4.62	4.53	4.31	3.99	3.84	4.95	4.26
79	3.39	3.75	3.81	4.38	4.44	4.84	4.50	3.86	3.45	2.88	2.94	2.90	3.73
1880	3.03	b 3.48	3.60	4.04	4.14	4.35	4.33	3.91	3.60	3.27	3.29	2.74	3.65
81	1.02	1.56	2.82	3.53	3.72	3.98	4.04	3.73	3.39	3.02	3.06	3.10	3.06
82	3.30	3.44	4.07	4.84	4.80	5.40	5.34	4.95	4.46	4.10	3.67	3.51	4.31
83	1.57	2.01	2.76	3.78	4.56	5.37	5.77	5.55	5.10	4.66	4.59	4.42	4.21
84	3.20	3.76	4.46	5.71	5.92	b 5.81	b 5.61	5.53	5.15	4.67	4.33	4.13	4.86
85	3.73	3.83	3.73	3.60	4.96	5.35	5.45	5.30	5.11	4.87	4.86	5.07	4.47
86	5.15	5.06	5.02	5.00	6.40	6.38	5.83	5.47	5.16	4.76	4.63	4.31	5.34
87	3.97	4.22	4.60	5.39	5.91	5.95	5.67	5.17	4.72	4.40	3.90	3.64	4.80
88	3.49	3.27	3.27	4.05	4.20	4.22	4.28	4.08	3.91	3.26	3.17	3.20	3.64
89	3.51	2.87	3.43	4.01	4.19	4.51	4.61	4.25	3.83	3.12	3.15	3.46	3.75
1890	4.10	4.13	4.64	4.98	5.28	5.09	5.74	b 5.00	b 4.79	4.28	4.22	3.44	4.73
91	3.41	3.48	4.30	5.13	4.93	4.82	4.38	3.99	3.50	2.83	2.80	2.42	3.79
92	3.23	1.83	1.98	2.97	3.16	3.80	4.21	4.08	b 3.67	3.44	3.09	3.10	3.11
93	2.27	1.71	2.29	3.06	4.80	5.12	4.81	4.27	4.17	3.60	3.20	3.06	3.55
94	3.16	3.44	3.49	3.83	4.04	4.61	4.40	3.51	3.27	3.18	2.95	2.39	3.47
95	2.16	1.33	1.59	2.64	2.97	2.81	2.51	2.36	2.11	1.77	1.56	1.72	2.13
96	1.80	1.96	1.86	3.06	3.46	3.29	3.17	3.02	2.84	2.32	2.22	2.04	2.56
97	1.91	1.75	2.25	3.19	3.34	3.73	3.64	3.62	3.07	2.87	2.30	2.37	2.81
98	2.44	2.52	2.53	3.21	3.54	3.59	3.32	3.24	2.85	2.53	2.56	2.61	3.00
99	2.70	2.56	2.72	3.25	3.66	3.54	3.66	3.27	2.81	2.40	2.26	2.25	2.94
1900	2.30	2.25	2.25	3.28	3.64	3.70	3.64	3.26	3.01	2.62	2.37	2.65	2.93
01	2.48	2.13	1.88	3.02	3.66	3.70	3.80	3.21	2.97	2.46	2.00	2.18	2.76
02	c 1.24	c 0.24	c 2.44	c 3.24	c 3.24	c 3.44	c 3.74	c 3.54	c 3.54	b 2.28	c 2.04	c 2.74	2.80
03	2.54	2.54	3.24	4.14	4.34	4.14	4.24	4.04	3.54	3.44	3.14	2.04	3.53
04	c 2.54	c 2.54	c 3.04	c 4.54	b 5.35	c 5.54	c 5.74	c 5.38	c 5.00	b 4.65	c 4.06	c 3.34	4.31
05	3.08	2.78	2.44	3.68	4.04	4.28	4.70	4.44	4.44	4.28	3.88	3.58	3.80
06	3.98	3.96	3.51	3.96	4.01	4.14	4.24	3.96	3.53	3.43	3.38	3.29	3.75
07	3.33	3.47	3.48	4.42	4.73	4.78	4.58	4.62	4.19	4.16	4.06	3.93	4.18
Mean	243.07	242.96	243.25	244.12	244.60	244.75	244.73	244.41	244.04	243.70	243.48	243.26	243.87

Authority, U. S. Lake Survey, except for supplied values.

a—Supplied from Oswego readings by formula, (Lock 27—240) = 0.9457 (Oswego—240)—1.845 assuming a mean fall during entire period.

b—Supplied from Oswego readings by formula, (Lock 27—240) = 0.9457 (Oswego—240)—1.845.

c—Deduced from the water records of the St. Lawrence canals furnished the International Waterways Commission.

Note.—Elevations depend on zero of gage, sill of Lock No. 27, 234.144 ft.

TABLE 16.

WATER LEVELS OF ST. LAWRENCE RIVER.

Monthly mean elevations of water surface of St. Lawrence River, at Lock No. 24, Morrisburg Canal, head of Rapide Plat, in feet above upper sill of old lock.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1880	8.32		8.70	9.49	9.74	9.95	9.89	9.26	8.84	8.34	8.61	7.83	9.01
81	8.09	6.74	7.94	8.77	9.03	9.36	9.86	9.17	8.53	7.89	8.48	8.35	8.31
82	8.54	8.89	9.55			10.77	10.53	10.22	9.89	9.46	8.63	8.53	9.47
83	7.57	5.90	7.66	9.14	9.90	10.78	11.15	11.05	11.06	10.12	9.53	9.38	9.48
84	7.49	8.15	12.41	10.90	11.78	11.61	11.31	11.15	10.85	9.83	9.20	8.64	10.21
85	7.90	7.18	7.53	8.61	10.21	10.91	10.74	10.58	10.09	10.05	9.94	10.39	9.48
86	10.18	10.09	10.32	11.55	11.84	11.71	11.22	10.62	10.40	10.09	9.86	9.60	10.91
87	8.77	10.40	11.13	11.13	11.44	11.41	11.06	10.46	10.07	9.65	8.99	8.48	10.23
88	7.79	6.85	7.80	9.38	9.87	9.83	9.46	9.28	8.97	8.43	8.41	8.26	8.98
89	8.71	8.16	7.96	9.80	9.46	9.93	10.05	9.79	9.13	8.32	7.96	8.77	8.98
1890	9.34	9.84	10.09	10.46		11.47	11.42	10.81	10.21	9.73	9.70	9.36	10.16
91	8.64	8.74	9.60	9.40	10.64	9.97	9.86	9.26	8.68	7.82	7.36	7.30	8.94
92	7.02	5.82	6.44	7.74	7.98	8.74	9.53	9.30	9.22	8.51	8.13	7.98	8.03
93	5.25	7.80	8.63	8.92	10.26	10.80	10.52	9.82	9.48	8.87	8.33	8.06	8.96
94	7.98	6.61	8.71	9.13	9.25	10.13	9.88	9.01	8.60	8.06	7.77	7.32	8.53
95	6.61	5.45	6.09	9.47	7.82	7.05	7.23	7.10	6.84	6.16	5.89	5.81	6.61
96	5.85	6.35	7.72	7.99	8.22	8.28	7.99	7.73	7.09	6.66	6.45	6.33	7.28
97	6.02	5.42	6.45	7.38	8.42	8.78	8.52	8.55	7.81	7.07	6.76	7.07	7.40
98	7.04	7.61	8.25	8.74	9.04	9.10	8.74	8.38	7.83	7.44	7.40	7.35	8.10
99	7.00	6.68	7.83	8.54	8.86	9.16	8.82	8.15	7.55	7.08	7.04	7.01	7.79
1900	6.91	6.89	7.16	8.50	8.88	8.98	8.84	8.22	7.90	7.40	7.12	7.39	7.87
01	7.29	7.00	7.14	8.14	8.65	9.03	8.73	8.37	8.18	7.65	7.09	7.04	7.86
e 02	7.00	5.80	7.80	8.60	8.70	8.90	9.10	9.40	8.11	8.00	8.30	7.10	8.13
e 03	8.00	7.70	8.90	8.90	9.11	9.80	9.11	9.80	9.10	8.90	8.00	7.70	8.84
e 04	6.90	7.10	7.80	9.80	10.50	10.10	11.00	10.96	10.26	10.00	9.26	8.20	9.31
e 05	7.10	10.40	9.20	9.10	9.10	9.46	9.90	9.90	9.70	9.40	9.00	8.90	9.27
e 06	9.08	8.78	9.57	9.00	9.35	9.41	9.53	9.18	8.65	8.44	8.25	8.22	8.96
e 07	8.05	8.45	9.39	10.30	10.07	10.17	10.34	10.00	10.02	9.90	9.19	9.17	9.88
Mean	7.87	7.84	8.44	9.26	9.55	9.85	9.79	9.47	9.02	8.58	8.22	8.09	8.75

Authority, U. S. Lake Survey, except for supplied values.

e.—Deduced from the water records of the St. Lawrence canals furnished the International Waterways Commission.

TABLE 17.

WATER LEVELS OF ST. LAWRENCE RIVER.

Monthly mean elevations of water surface of St. Lawrence River, at Lock No. 21, Cornwall Canal, head of Long Sault Rapids, in feet above upper sill of old lock.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1870	10.99	10.94	10.70	12.00	12.54	12.43	12.25	11.85	11.20	11.07	10.63	10.36	11.41
71	9.89	9.71	10.32	10.74	11.06	11.08	10.91	10.54	10.24	9.87	9.34	9.08	10.23
72	8.44	7.75	8.02	8.78	9.21	9.53	9.67	9.37	9.11	8.97	9.06	8.67	8.88
73	9.80	8.98	9.20	10.10	10.81	10.97	10.90	10.58	10.34	9.92	9.74	10.02	10.09
74	10.30	10.31	11.06	11.08	11.19	11.30	11.23	10.96	10.41	10.13	9.74	9.33	10.59
75	8.41	7.42	8.53	9.41	9.88	10.06	10.12	9.92	9.65	9.37	9.20	9.11	9.26
76	9.46	9.83	10.16	11.43	11.91	12.11	12.15	11.71	11.18	11.02	10.87	10.64	11.01
77	10.04	10.06	10.17	10.41	10.89	10.51	10.56	10.27	9.87	9.43	9.27	9.50	10.06
78	9.44	9.40	10.21	10.92	10.92	10.92	10.85	10.84	10.73	10.41	10.33	11.00	10.47
79	10.44	9.51	9.52	10.00	10.86	10.84	10.98	10.39	9.99	9.58	9.21	9.10	10.09
1880	9.40	9.38	9.32	10.32	10.45	10.61	10.55	10.09	9.82	9.46	9.39	9.24	9.94
81	8.18	7.18	9.02	9.77	10.01	10.25	10.29	9.96	9.50	9.33	9.35	9.30	9.35
82	9.60	9.54	10.40	10.93	10.80	11.28	11.38	11.01		10.21	9.75	9.63	10.39
83	9.11	8.91	9.97	9.99	10.64	11.20	11.47	11.35	11.21	10.63	10.06	10.42	10.43
84	10.59	10.70	10.43	11.73	11.82	11.86	11.80	11.37	10.96	10.54	10.22	9.94	10.99
85	9.90	9.93	9.50	9.87	10.63	11.24	11.22	11.02	10.54	10.06	10.76	10.99	10.56
86	10.80	9.57	10.50	11.91	12.17	12.02	11.70	11.32	11.02	10.86	10.53	10.42	11.05
87	11.08	11.79	11.81	11.82	11.80	11.77	11.82	11.05	10.54	10.26	9.72	9.62	11.04
88	9.52	8.81	9.62	10.09	10.18	10.23	10.24	10.20	9.88	9.55	9.48	9.53	9.78
89	9.68	8.94	9.30	10.23	10.24	10.61	10.75	10.48	10.00	9.51	9.21	9.80	9.90
1890	10.24	10.22	10.72	11.07	11.42	11.88	11.78	11.21	10.94	10.83	10.62	10.39	10.91
91	10.08	9.80	10.55	11.33	11.18	10.66	10.50	10.15	9.75	9.06	8.75	8.79	10.05
92	8.66	7.67	8.37	9.29	9.20	9.86	10.40	10.18	10.14	9.73	9.48	15.52	9.85
93	14.80	15.20	15.20	16.32	10.90	11.12	10.94	10.20	10.33	9.78	9.51	9.21	11.98
94	9.32	8.18	9.73	9.99	10.15	10.66	10.44	9.94	9.55	9.26	9.04	8.62	9.57
95	8.46	6.95	7.28	8.86	8.97	8.92	8.84	8.62	8.23	7.84	7.64	7.57	8.18
96	8.20	8.05	8.54	9.28	9.42	9.38	9.19	9.02	8.64	8.10	8.32	7.99	8.73
97	7.55	7.46	8.40	9.07	9.48	9.06	9.59	9.16	9.01	8.45	8.32	8.48	8.79
98	8.48	9.59	9.51	9.66	9.82	9.84	9.64	9.37	9.01	8.82	8.67	8.77	9.25
99	8.70	8.54	9.62	9.48	9.73	9.92	9.72	9.25	8.85	8.42	8.38	8.54	9.10
1900	8.39	8.89	8.55	9.66	9.87	9.91	9.86	9.58	9.30	8.83	8.71	9.00	9.02
01	8.86	9.21	9.02	9.57	9.88	10.02	9.75	9.50	9.27	8.93	8.44	8.61	9.26
c 02	8.80	12.40	9.00	9.40	9.70	9.90	10.10	10.20	9.10	9.00	9.00	9.00	9.77
c 03	8.11	8.80	9.00	10.40	10.00	10.10	10.00	10.50	10.20	9.70	9.10	8.10	9.65
c 04	8.12	10.10	9.30	10.40	9.70	11.20	11.20	11.40	10.90	10.20	9.10	9.10	10.06
c 05	8.10	7.40	7.80	9.80	9.80	10.00	10.22	10.21	10.13	9.88	9.88	9.28	9.35
c 06	9.80	9.18	9.25	9.50	9.88	9.88	9.75	9.53	9.12	8.82	8.86	9.12	9.36
c 07	9.14	8.94	9.32	10.12	10.37	10.30	10.20	10.26	9.87	9.89	9.78	9.82	9.83
Mean	9.44	9.41	9.62	10.33	10.46	10.62	10.60	10.35	9.97	9.65	9.42	9.52	9.96

Authority, U. S. Lake Survey, except for supplied values.

c.—Deduced from the water records of the St. Lawrence canals furnished the International Waterways Commission.

TABLE 19.

DISCHARGE FROM LAKE SUPERIOR.

Monthly mean outflow from Lake Superior, through St. Mary's River, in 100 cubic feet per second.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	942	880	875	932	1015	1062	1062	1075	1057	1066	1035	932	[illegible]
61	875	813	780	870	1040	1067	1122	1126	1092	1098	1018	919	[illegible]
62	836	778	785	794	962	986	968	1020	1042	1027	940	875	[illegible]
63	820	785	746	780	813	799	840	986	976	957	864	817	[illegible]
64	739	686	702	702	771	810	840	845	886	808	760	714	[illegible]
65	661	654	634	721	866	965	1045	1068	1057	1009	884	801	[illegible]
66	723	670	670	769	859	907	962	1038	962	947	889	905	[illegible]
67	839	799	735	801	834	978	1062	1096	1041	1094	935	850	[illegible]
68	801	861	744	783	907	891	951	955	981	944	979	846	[illegible]
69	808	746	642	771	906	908	997	1105	1287	1186	1057	924	[illegible]
1870	854	804	806	834	912	982	945	949	974	957	903	886	[illegible]
71	744	707	644	677	808	903	944	926	937	891	840	780	[illegible]
72	693	674	619	610	615	834	946	1020	1086	1002	907	843	[illegible]
73	771	732	737	741	870	900	1002	1089	1075	1046	907	942	[illegible]
74	815	778	783	725	822	931	1006	1020	1016	1045	985	972	[illegible]
75	886	806	790	856	928	907	1016	1020	1065	1055	990	961	[illegible]
76	854	843	782	793	955	1083	1200	1211	1218	1142	1078	986	[illegible]
77	896	908	877	860	850	980	976	1004	949	955	908	886	[illegible]
78	815	785	732	725	792	852	877	868	891	826	808	787	[illegible]
79	685	679	616	646	693	695	734	741	723	730	688	696	[illegible]
1880	650	643	622	625	695	670	828	866	883	882	809	824	[illegible]
81	783	730	734	709	906	880	935	986	950	1036	1013	957	[illegible]
82	830	789	741	730	834	845	926	949	935	914	900	898	[illegible]
83	799	716	718	734	782	917	889	956	880	845	830	780	[illegible]
84	737	698	672	653	715	761	792	801	817	838	841	801	[illegible]
85	762	737	704	695	799	877	919	949	914	873	856	797	[illegible]
86	707	670	670	666	776	913	952	954	952	960	842	744	[illegible]
87	698	661	654	623	704	806	863	986	934	875	832	728	[illegible]
88	691	813	634	622	760	864	962	990	973	960	923	776	[illegible]
89	723	664	670	668	780	916	870	872	870	840	780	704	[illegible]
1890	714	695	682	658	682	736	870	852	830	816	788	726	[illegible]
91	680	612	582	616	704	694	716	716	704	716	694	638	[illegible]
92	620	648	612	544	646	718	748	748	760	736	652	626	[illegible]
93	519	492	464	531	692	728	778	790	786	755	748	644	[illegible]
94	602	587	564	538	623	686	804	866	871	779	680	604	[illegible]
95	747	721	682	679	744	833	873	875	907	890	832	820	[illegible]
96	727	697	648	701	810	886	918	931	907	916	822	810	[illegible]
97	767	709	712	737	803	871	912	943	910	871	840	788	[illegible]
98	670	627	590	620	686	725	810	841	886	836	804	780	[illegible]
99	699	666	648	657	819	903	940	968	1004	942	926	917	[illegible]
1900	782	770	722	720	764	777	818	857	948	954	974	900	[illegible]
01	818	764	725	742	798	814	888	920	885	798	788	728	[illegible]
02	670	625	613	625	687	725	760	782	770	746	757	731	[illegible]
03	660	624	610	640	709	774	795	810	812	838	819	780	[illegible]
04	666	630	598	645	700	738	760	771	787	813	796	752	[illegible]
05	738	712	670	747	801	834	899	923	958	965	923	904	[illegible]
06	831	760	720	723	792	843	880	873	878	885	823	779	[illegible]
07	715	683	668	712	754	810	840	880	917	919	891	848	[illegible]
Mean	745	701	665	700	796	857	906	937	926	913	875	804	[illegible]

TABLE 20.

DISCHARGE FROM LAKE MICHIGAN-HURON.

Monthly mean outflow from Lake Michigan-Huron, through Detroit River, in 100 cubic feet per second.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	2125	1447	1942	3051	2214	2326	2002	1995	1894	2176	1935	2250	2046
61	e2206	1723	2168	2260	2164	2374	2234	2409	2358	2399	2262	2264	2237
62	2053	1521	2024	2442	2358	2393	2270	2438	2411	2398	2362	2212	2248
63	2153	2040	1878	2122	2207	2304	2240	2238	2263	2302	2283	2187	2200
64	e2378	2043	2049	e2201	2309	2453	2276	2241	2310	2121	2162	2133	2231
65	1894	1446	1693	2052	2204	2341	2323	2240	2321	2276	2179	2067	2067
66	e2028	1928	1850	e1964	2098	2182	2268	2256	2243	2228	2295	2272	2134
67	1881	1906	1641	e2118	2289	2427	2331	2420	2237	2231	2154	2096	2165
68	e2062	1733	2179	2095	2209	2366	2211	2180	2146	2064	2016	1998	2095
69	1844	1662	1907	1976	1848	2020	2184	2211	2192	2091	2121	2133	1994
1870	e2021	1757	1853	2154	2212	2254	2456	2451	2373	2248	2248	2310	2193
71	2089	1670	e2257	2170	2420	2448	2466	2415	2319	2186	2174	2234	2263
72	1995	2052	1934	e1998	2100	2217	2059	2132	2126	2146	2094	2005	2064
73	1796	1924	2099	e1991	1997	2133	2195	2201	2202	2141	2134	2067	2071
74	1470	1953	1947	2053	1996	2108	2168	2164	2200	2185	2183	2027	1988
75	2006	2045	2022	2027	2157	2157	2218	2175	2140	2177	2158	1980	2114
76	2060	2160	e2188	2240	1965	2311	2627	2618	2389	2252	2300	e2283	2307
77	e2271	1947	1942	1783	1799	2251	2300	2277	2164	2232	1943	2149	2043
78	2064	1518	1546	2217	2231	2271	2216	2230	2178	2168	2086	1855	2066
79	1771	1482	1849	2052	1940	2078	2104	2052	2068	1961	1978	1984	1943
1880	1931	1709	1903	1974	1963	2176	2005	2216	2183	2089	2053	2054	2028
81	1756	1998	1891	2035	2053	2182	2178	2209	2247	2137	2266	2232	2100
82	2225	2045	2194	2152	2268	2206	2380	2615	2321	2271	2251	e2139	2263
83	e2238	2226	1856	2155	2230	2434	2784	2716	2538	2402	2307	2211	2330
84	1514	1703	2426	2426	2444	2531	2611	2489	2410	2307	2336	2284	2230
85	e2208	2352	e2264	e2267	2288	2445	2276	2432	2296	2217	2276	2304	2304
86	1677	1490	2008	2116	2425	2432	2618	2405	2403	2364	2296	2403	2244
87	2289	2223	1985	2123	2202	2361	2319	2216	2233	2217	2109	2018	2204
88	2090	2086	1922	2104	2004	2130	2308	2177	2186	2131	2079	1992	2194
89	2089	1701	1716	1792	1934	2100	2086	2097	2113	2020	1998	1817	2004
1890	1940	1797	1745	1832	1839	1964	2046	2066	1994	1919	1880	1875	1955
91	1718	1809	1834	1830	1945	1885	1861	1982	1943	1878	1912	1873	1913
92	1683	1425	1508	1767	1787	1864	1908	1936	1951	1905	1843	1783	1844
93	1464	1514	1851	1883	1817	1950	2047	2052	2034	1988	1990	1955	1879
94	1676	1656	1877	1867	1981	2045	2048	2051	2026	1971	1952	1882	1940
95	e1878	e1942	1985	1733	1814	1861	1896	1895	1868	1794	1722	1748	1837
96	1736	1410	1840	1981	1985	1791	1885	1866	1837	1942	1940	1882	1736
97	1925	e1784	1907	1849	1850	1871	1991	1932	1926	1886	1916	1907	1891
98	1756	1482	1386	1946	1818	1899	1946	1931	1904	1899	1909	1904	1889
99	1947	e1836	1366	1685	1812	1925	2022	2031	2015	1923	1953	1922	1856
1900	1736	1778	1874	1780	1796	1868	1912	1957	1978	1953	1974	1911	1878
01	1719	1410	1548	1181	1706	1899	2052	2084	2039	1982	1993	1935	1798
02	1822	1464	1827	1816	1818	1926	2064	2005	1944	1905	1846	1919	1838
03	1966	1851	1857	1879	1909	1911	1968	1978	1967	1900	1910	2138	1937
04	1812	1663	e1825	2035	1909	2031	2063	2103	2079	2035	1992	2019	1950
05	1840	1534	1676	1947	1922	2066	2118	2134	2064	2052	2004	1942	1922
06	1991	1846	1600	1905	1990	2024	2089	2083	2030	2021	1994	1895	1933
07	1779	1711	1749	1931	1982	1990	2075	2026	2047	2017	1961	1983	1934
Mean	1916	1786	1865	1996	2047	2143	2196	2197	2157	2110	2075	2042	2043

e—St. Clair River discharge used.

TABLE 21.

DISCHARGE FROM LAKE ERIE.

Monthly mean outflow from Lake Erie, through Niagara River, in 100 cubic feet per second.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	2321	2178	2365	2423	2475	2486	2426	2375	2304	2244	2248	2256	2324
61	2161	2045	2126	2275	2485	2521	2474	2436	2431	2387	2410	2401	2347
62	2245	2237	2259	2471	2521	2551	2562	2439	2378	2294	2287	2291	2394
63	2272	2290	2261	2375	2418	2400	2367	2346	2264	2173	2101	2137	2311
64	2041	2035	2061	2157	2332	2257	2268	2205	2165	2105	2091	2153	2162
65	2022	1846	1904	2060	2183	2195	2201	2165	2171	2112	2060	2061	2080
66	1971	1887	1942	2077	2125	2206	2245	2189	2160	2151	2150	2197	2112
67	2005	1975	2055	2112	2224	2230	2206	2203	2123	2068	1970	1964	2119
68	1891	1765	1878	2048	2149	2261	2270	2125	2077	1987	1976	1973	2035
69	1941	1878	1973	2025	2149	2261	2242	2204	2251	2187	2078	2203	2150
1870	2239	2231	2164	2206	2256	2285	2294	2251	2214	2234	2188	2206	2279
71	2123	1967	2068	2185	2243	2273	2263	2215	2188	2045	2039	1973	2137
72	1935	1838	1796	1835	1917	2016	2026	2005	1995	1941	1883	1885	1919
73	1835	1792	1796	2061	2217	2265	2267	2231	2180	2094	2072	2206	2081
74	2209	2237	2221	2246	2267	2301	2327	2267	2170	2079	2009	2005	2199
75	1922	1840	1860	1939	2052	2149	2187	2176	2157	2056	2047	2143	2042
76	2102	2183	2332	2446	2538	2578	2547	2495	2435	2317	2285	2237	2387
77	2196	2105	2041	2124	2181	2217	2204	2209	2234	2152	2159	2235	2161
78	2213	2106	2213	2286	2256	2275	2286	2217	2266	2227	2206	2271	2250
79	2137	2065	2051	2118	2149	2167	2212	2140	2077	2033	1966	2010	2068
1880	2148	2103	2134	2145	2207	2251	2291	2213	2172	2061	2066	2043	2154
81	1931	1905	1966	2112	2205	2201	2264	2182	2119	2121	2105	2200	2118
82	2262	2220	2230	2267	2416	2474	2474	2416	2262	2265	2213	2125	2330
83	2064	2061	2115	2136	2234	2437	2500	2462	2397	2332	2265	2230	2279
84	2209	2215	2246	2270	2426	2475	2426	2375	2261	2215	2126	2155	2296
85	2061	1984	1941	2112	2286	2434	2441	2438	2400	2290	2267	2422	2213
86	2286	2159	2103	2256	2372	2416	2436	2357	2267	2287	2232	2246	2290
87	2161	2212	2263	2272	2427	2465	2423	2322	2264	2256	2135	2170	2297
88	2094	1964	1971	2131	2187	2197	2251	2225	2142	2098	2064	2133	2117
89	2081	2041	1963	2088	2075	2186	2196	2174	2084	1970	1970	2041	2066
1890	2178	2138	2191	2261	2342	2436	2384	2327	2152	2130	2196	2133	2233
91	2072	2046	2077	2106	2084	2060	2091	2025	1966	1903	1891	1897	2014
92	1878	1733	1775	1864	2054	2246	2280	2205	2143	2065	1978	1973	2035
93	1906	1796	1861	2006	2174	2258	2234	2096	2038	2006	2001	1963	2025
94	1903	1906	1931	1974	2088	2181	2180	2040	2002	2003	1962	1923	2013
95	1896	1749	1733	1777	1860	1873	1867	1838	1842	1792	1691	1744	1804
96	1775	1760	1667	1796	1891	1896	1933	1983	1891	1838	1842	1797	1840
97	1875	1761	1886	2004	2101	2097	2088	2066	1984	1886	1395	1921	1946
98	1893	1870	1951	2088	2119	2138	2077	2088	1981	1943	1945	1978	2005
99	1974	1875	1939	1973	2016	2079	2066	1983	1941	1880	1866	1964	1951
1900	1891	1878	1923	1999	2086	2064	2081	2094	1978	1893	1927	1912	1966
01	1876	1755	1712	1760	1796	1896	1936	1897	1906	1881	1831	1837	1837
02	1836	1706	1739	1855	1908	1975	2130	2110	2051	2052	1995	2009	1945
03	1961	1887	1993	2154	2139	2184	2194	2110	2068	2045	1946	1995	2040
04	1762	1813	1991	2170	2252	2217	2264	2225	2157	2108	2053	1993	2035
05	1908	1797	1816	1917	2049	2186	2264	2209	2161	2112	2089	2086	2042
06	2028	1936	1980	1977	2025	2075	2091	2078	2028	2020	2086	2068	2021
07	2185	2070	2014	2106	2157	2220	2276	2200	2148	2145	2126	2108	2148
Mean	2060	1981	2012	2116	2192	2251	2283	2203	2152	2095	2063	2063	2122

Discharge values include a flow of 1000 c. f. s. through Erie Canal, and one of 1100 c. f. s. through Welland Canal.

TABLE 22.

DISCHARGE FROM LAKE ONTARIO.

Monthly mean outflow from Lake Ontario, through St. Lawrence River, in 100 cubic feet per second.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1860	2630	2681	2699	2690	3583	3062	3148	3060	3027	2767	2794	2678	2916
61	2567	2515	2754	2836	3267	3390	3313	3215	3072	3141	3147	2949	3022
62	2789	2656	2908	3103	3512	3404	3484	3330	3075	2900	2788	2642	3094
63	2699	2696	2725	2956	3218	3267	3128	3077	2850	2790	2722	2619	2887
64	2544	2496	2522	2696	3146	3346	3140	3089	2834	2740	2730	2652	2811
65	2778	2626	2872	3000	3079	3083	3040	3042	2889	2584	2501	2350	2794
66	2396	2288	2397	2432	2665	2643	2832	2791	2772	2720	2655	2505	2556
67	2433	2426	2642	2629	2278	2370	2243	2090	2896	2689	2445	2111	2787
68	1689	2040	2126	2300	2605	2725	2699	2909	2552	2370	2536	2266	2361
69	2223	2257	2323	2480	2794	3076	3091	3029	2983	2845	2717	2652	2712
1870	2748	[2]3040	[2]2760	3232	3505	3441	3432	3296	2706	2681	2586	2400	2944
71	2471	2619	2463	2668	2722	3131	3021	2957	2749	2722	2561	2132	2636
72	[2]2662	[2]1873	[2]1945	2114	2448	2453	2675	2665	2788	2566	2177	1978	2294
73	1967	1902	2019	2592	3016	3121	3183	2746	2613	2466	2447	2351	2547
74	2351	[2]2623	2549	2612	2933	2960	3045	3039	2962	2851	2877	2166	2707
75	[2]1549	[2]1579	[2]1631	2435	2438	2440	2484	2478	2230	2329	2402	2363	2344
76	2389	[2]2478	[2]2563	2861	3041	3033	3112	3164	3042	2672	2638	2748	2820
77	[2]2100	2337	[2]2452	2706	2546	2560	2424	2394	2380	2686	2433	2345	2464
78	[2]2273	[2]2342	2493	2670	2270	2678	2990	2920	2816	2792	2786	2711	2656
79	[2]2396	[2]2278	[2]2361	2650	2950	2882	2737	2584	2739	2734	2597	2946	2696
1880	2184	2424	2355	2513	2399	2896	2710	2597	2449	2276	2312	2152	2429
81	[2]1736	[2]1722	[2]2230	2646	2841	2710	2899	2805	2278	2345	2313	2261	2446
82	[2]2042	[2]2267	2553	2579	2975	2901	2970	2907	2948	2670	2596	2355	2684
83	[2]1950	[2]1872	[2]2313	2411	2527	2862	2180	2141	2001	2986	2884	2802	2342
84	[2]2184	[2]2234	[2]2726	3039	3348	3294	3153	2944	2962	2876	2857	2454	2915
85	[2]2270	[2]2131	[2]2197	2600	2771	2885	2920	2854	2792	2764	2677	2570	2642
86	[2]2767	[2]2397	[2]2983	3159	3206	3172	3140	2928	2780	2539	2350	2614	2942
87	[2]2460	[2]2650	[2]2796	3075	3312	3074	3[illegible]5	2842	2694	2685	2519	2449	2782
88	2235	[2]1996	[2]2072	2555	2500	2835	2599	2615	2311	2473	2473	2266	2393
89	2405	[2]2307	[2]2263	2594	2801	2878	2619	2764	2571	2664	2228	2264	2506
1890	[2]2589	2614	[2]2743	2890	3128	3030	3158	2643	2966	2816	2856	2501	2835
91	[2]2404	[2]2425	[2]2649	3122	3083	2986	3530	2374	2282	2440	2399	2093	2531
92	[2]2089	[2]1951	[2]1974	2392	2710	2549	2400	2436	2655	2287	2232	2304	2306
93	[2]1752	[2]1915	[2]2077	2353	2040	2894	2980	2826	2605	2519	2400	2230	2434
94	2297	[2]1990	[2]2426	2672	2867	2796	2746	2500	2410	2319	2136	2206	2440
95	1980	[2]1859	[2]1774	2034	2197	2302	2134	2006	1666	1794	1710	1625	1916
96	[2]1825	1923	[2]1956	2230	2252	2305	2130	2083	1985	1994	1754	1645	2002
97	1890	[2]1783	[2]1976	2022	2321	2198	2280	2200	2215	1972	2105	2120	2096
98	[2]2074	[2]2143	2191	2560	2878	2886	2801	2501	2572	2527	2390	2069	2435
99	2078	[2]2063	2100	2389	2644	2634	2808	2434	2294	2180	2133	2034	2306
1900	2023	[2]2063	[2]1566	2005	2781	2578	2530	2530	2141	2135	2151	2226	2286
01	[2]2151	1896	1998	2384	2442	2535	2404	2414	2305	2235	2182	2133	2260
02	[2]1780	[2]1522	[2]2130	2227	2411	2434	2590	2573	2451	2527	2196	2265	2242
03	[2]2070	2049	2236	2746	2711	2661	2789	2673	2672	2389	2272	2176	2437
04	[2]1973	1940	2043	2260	2675	2668	2767	2604	2726	2640	2605	2160	2470
05	[2]1966	[2]1779	[2]1886	2211	2449	2066	2643	2776	2671	2475	2536	2220	2350
06	[2]2403	2344	2191	2518	2529	2527	2606	2551	2464	2263	2249	2239	2414
07	[2]2366	[2]2307	[2]2291	2664	2741	2730	2743	2672	2590	2609	2467	2294	2513
Mean	2250	2188	2333	2606	2795	2835	2836	2750	2621	2536	2450	2341	2544

Note—21, 24 and 27 indicate that St. Lawrence River discharges were derived from gage observations taken at Locks 21, 24 and 27, respectively.

WILLIAMS EXHIBIT 34.

CONSISTING OF

A series of Tables, Charts and Plates based on Williams Exhibits 1 to 33 incl., and 35 in this case, and the Records of United States Lake Survey, Reports of the Chief of Engineers, U. S. A., of the United States Geological Survey and of the United States Weather Bureau; and of Officials of certain States and Municipalities.

Compiled under the direction of
GARDNER S. WILLIAMS.

Sheet No. 1.

CHICAGO SANITARY DISTRICT.

INDEX.

Table	Sheets	Name
I.	1	St. Clair Discharge Observations (Harbor Beach Gage).
II.	1	St. Clair Discharge Observations (Grand Trunk Gage).
III.	1	Niagara Discharge Observations (Bridge Section).
IIIa.	3	Niagara Discharge Observations (Bridge Section inc. 1907-08).
IV.	1	Niagara Discharge Observations (Open Section).
V.	1	St. Lawrence Discharge Observations.
VI.	2	St. Clair River Discharge Observations (Gorge & Dry Dock Sections).
VII.	1	St. Clair River Discharge Observations (Gorge & Dry Dock Sections).
VIII.	1	Niagara River (Comparison Bridge and Open Sections).
IX.	1	Niagara River (Comparison Bridge and Open Sections).
X.	1	Niagara River (Comparison Bridge and Open Sections).
XI.	1	Q for Niagara River (Bridge Section).
XII.	1	Q for Niagara River (Open Section).
XIII.	1	St. Clair River Equation (Complainant's Groups 1899, 1900, 1902).
XIV.	1	St. Clair River Equation (Complainant's Groups 1899, 1900, 1902, 1908).
XV.	1	St. Clair River Equation (Complainant's Groups 1899, 1900, 1901, 1902, 1908).
XVI.	1	Weighted Elevations & Differences (Lakes Huron & Erie, 1899-1908, incl.).
XVII.	1	Weighted Elevations & Differences (Lakes Huron & St. Clair, 1899-1908, incl.).
XVIII.	2	Differences in Elevation, Open Season (Huron-St. Clair, St. Clair-Erie, Huron-Erie).

Sheet No. 2.

CHICAGO SANITARY DISTRICT.

INDEX.

Table	Sheet	Name
XVIIIa.	2	Differences in Elevation, Closed Season (Huron-St. Clair, St. Clair-Erie, Huron-Erie).
XIX.	2	Differences in Elevation, Full Year (Huron-St. Clair, St. Clair-Erie, Huron-Erie).
XX.	1	Q for St. Clair River, Complainant's Groups.
XXI.	1	Relative Fluctuation of Lakes.
XXII.	1	Equations of Discharge of St. Clair River (Lake St. Clair Constant), 1899, 1900, 1901, 1902 and 1908.
XXIII.	1	Equations of Discharge of St. Clair River (Lake Huron Constant), 1899, 1900, 1901, 1902 and 1908.
XXIV.	1	Weighting of Increments in Tables XXII and XXIII.
XXV.	1	Equations of Discharge of St. Clair River (Lake St. Clair Constant), 1908-1910.
XXVI.	1	Equations of Discharge of St. Clair River (Lake Huron Constant), 1908-1910.
XXVII.	1	Weighting of Increments in Table XXV and XXVI.
XXVIII.	3	St. Clair River, Discharge at Constant Stages 1899-1902.
XXIX.	1	St. Clair River, Variations of Groups from Mean 1899-1902.
XXX.	1	St. Clair River, Corrected Discharge of Groups. St. Clair Change=66 2/3% Huron Change 1899-1902.
XXXI.	1	St. Clair River Increment (1899-1902). Normal St. Clair =66 2/3% Huron.
XXXII.	1	St. Clair River Corrected Discharge of Groups. St. Clair Change=89% of Huron Change.

Sheet No. 1.

CHICAGO SANITARY DISTRICT.

INDEX.

Table	Sheet	Name
XXXIII.	1	St. Clair River Increment (1899-1902). Normal St. Clair =80% Huron.
XXXIV.	4	St. Clair River, Discharge at Constant Stages, 1908-1910.
XXXV.	1	St. Clair River, Variations of Groups from Mean, 1908-1910.
XXXVI.	1	St. Clair River, Corrected Discharge of Groups. St. Clair Change=66 2/3% of Huron Change.
XXXVII.	1	St. Clair River Increment (1908-1910). Normal St. Clair =66 2/3% Huron.
XXXVIII.	1	St. Clair River, Corrected Discharge of Groups. St. Clair Change=80% of Huron Change.
XXXIX.	1	St. Clair River Increment (1908-1910). Normal St. Clair =80% Huron.
XL.	3	Q for St. Clair River, Defendant's Equation.
XLI.	2	St. Lawrence River, Discharge at Constant Stages.
XLII.	1	St. Lawrence Increment. Three Points Section (Ogdensburg Gage).
XLIII.	1	St. Lawrence Discharge (Complainant's Equation).
XLIIIa.	1	St. Lawrence Discharge (Defendant's Equation).
XLIV.	1	Relative Fluctuations of Lakes Ontario and Erie.
XLV.	1	Niagara Discharge (Buffalo Gage).
XLVa.	5	Niagara Discharge at Constant Stage.
XLVI.	1	Niagara Increment (Buffalo and Amherstburg Gages).
XLVIa.	1	Niagara Increment (Buffalo and Amherstburg Gages).
XLVIb.	1	Niagara Increment (Amherstburg Gage).
XLVII.	1	Niagara Increment (Cleveland Gage).
XLVIIa.	1	Niagara Increment (Cleveland Gage).

Sheet No. 4.

CHICAGO SANITARY DISTRICT.

INDEX.

Table	Sheet	Name
XLVIII.	2	Precipitation on Great Lakes.
XLVIIIa.	3	Annual Precipitation (Various Stations).
XLIX.	2	Elevations of Lake Ontario.
L.	2	Elevations of Lake Superior.
LI.	1	Elevations of Lakes and Differences in Periods.
LII.	1	Elevations of Lakes and Differences in Periods.
LIII.	2	Dredging.
LIV.	6	Relative Fluctuations of Lakes St. Clair & Erie (Full Year).
LV.	4	Relative Fluctuations of Lakes St. Clair & Erie (Open Season).
LVI.	1	Winter Temperatures.
LVII.	1	Great Lakes Drainage Areas.
LVIII.	1	Comparisons of River Discharges.
LIXa.	1	Runoff from Drainage Basis (Summary).
LIXb.	1	Runoff from Huron-Michigan Drainage.
LIXc.	14	Runoff from Lake Michigan Drainage.
LIXd.	5	Runoff from Lake Huron Drainage.
LIXe.	7	Runoff from Lake Erie Drainage.
LIXf.	11	Runoff from Lake Ontario Drainage.
LXa.	2	Summary Rainfall.
LXb.	5	Precipitation on Huron-Michigan.
LXc.	3	Precipitation on Erie.
LXd.	3	Precipitation on Ontario.

Sheet No. 5.

CHICAGO SANITARY DISTRICT.

INDEX.

Table	Sheets	Name
LXIa.	2	Temperatures of Air and Water (Summary).
LXIb.	5	Temperatures of Air and Water (Water Works Pumping Stations).
LXIc.	6	Temperatures of Air and Water (U. S. Lake Survey).
LXId.	5	Surface Water Temperatures.
LXII.	1	Meteorological Records at Rochester.
LXIII.	1	Effect of Livingstone Channel.
LXIV.	1	Haskell Current Meter Results.
LXV.	1	Lake Elevations Prior and Subsequent to 1900.
Chart		
I.		Lower Detroit River Gage Relations.
II.		Plottings of Detroit River Slope.
III.		Discharge of Trenton Channel.
IV.		Discharge of Stony Island Channel.
V.		Discharge of Livingstone Channel.
VI.		Discharge of Lime Kiln Channel.
Plate		
I.		Complainant's Exhibit No. 1.
II.		Complainant's Exhibit No. 2.
III.		Complainant's Exhibit No. 3.
IV.		Complainant's Exhibit No. 4.

Sheet No. 6.

CHICAGO SANITARY DISTRICT.

INDEX.

Plate	Name
V.	Defendant's Discharge Curve for St. Clair River.
VI.	Defendant's Discharge Curve for St. Lawrence River.
VII.	Map of Head of St. Clair River.
VIII.	Map of Head of St. Clair River.
IX.	Cross Sections of St. Clair River. Niagara River Bridge Section. Niagara River Open Section. Sanitary District Canal.
X.	Profile of Connecting Water Between Lakes Huron & Erie.
XI.	Graphic Comparisons of Discharges.

Williams Ex. 34. Table 1

Chicago Sanitary District

St. Clair Discharge Observations

Showing variation of Q for same elevations.
Huron by Harbor Beach Gage.
St. Clair by St. Clair Flats Gage

No.	Huron Elevation	St. Clair Elevation	Discharge	Difference	Per. cent Variation from Mean
29 57	581.19	575.36	206600 205300	1300	0.364
32 41	581.22		210300 209300	1000	0.237
19 117	580.68	575.36	193900 192900	1000	0.258
113 207	580.69		199200 192800	3400	0.890
16 53	580.91		206700 200700	6000	1.473
12 153 124	580.62	575.26	199000 191600 190400	7400 9600 1200	1.834 4.209 0.314
119 120	580.81		197900 197000	1900	0.496
222 233	580.59	575.21	190100 188000	2100	0.555
96 279	580.30	575.16	182400 179000	3400	0.940
99 100	580.31		188200 182200	6000	1.619
237 236	580.32		189500 184700	4800	1.307
47 36	581.02		206400 204300	2100	0.511
179 181 183	580.92	574.96	207900 206100 203600	1200 1300 2500	0.289 0.413 0.601
133 136	580.60	574.86	198400 197200	1200	0.304
138 140 142	580.48	574.81	196600 190000 190200	600 6700 3800	0.134 1.633 1.302
Mean			195900	3305	

1632 Aver. variation from mean discharge = 0.844 %.

Williams Ex. 34 — Chicago Sanitary District. — Table II

St. Clair Discharge Observations

Showing variation of Q for same elevations.

Huron by Grand Trunk Gage

St Clair by St Clair Flats Gage

1899, 1900, 1901 App. EEE Page 2835 1902

Nos.	Huron Elevation	St. Clair Elevation	Discharge	Diff.	Percent Variation from Mean
33	579.362	575.20	191600		
34	.359		190400	1200	0.314
15a	579.379	575.30	196400		
19a	.376		193300	3100	0.796
29	579.493	575.20	192900		
30	.486		191000	1900	0.496
17a	579.558	575.30	205900		
52a	.560		199900	6000	1.478
21	579.656	575.30	199300		
23a	.655		205100	5800	1.433
27a	579.709	575.50	205300		
35a	.786		196700	8600	2.140
33a	579.847	575.50	206000		
34a	.850		206800	800	0.194
24a	d579.850	575.40	207100		
45a	d .850		210900	3800	0.909
37a	579.883	575.50	205300		
38a	.883		208200	2900	0.702
29a	579.890	575.50	206800		
42a	d .890		208300	1500	0.361
30a	579.951	575.50	207200		
41a	d 950		209900	2700	0.647
3	579.081	575.10	188200		
8	.076		182400	5800	1.565
6	579.398	575.10	192900	1800	0.469
11	403		191100	400	0.104
56a	402		192500	1400	0.364
44	579.483	574.80	203400		
64a	484		209200	5800	1.407
133	579.484	574.75	212400		
135	484		213900	1500	0.352
75a	579.595	574.80	207200		
76a	596		212500	5300	1.263
Page 2832 1900 EEE Sandusky	579.209	575.10	*185000		
Sandusky	.20		178900		
Mean			201515	3350	

*Readings not used in getting mean.

*1875 Aver. variation from mean discharge = 0.631%

Williams Ex. 34 *Chicago Sanitary District* *Table III.*

Niagara Discharge Observations

Showing Variations of Q at Bridge Section

for Same Elevation of Lake Erie by Buffalo Gage

Nos	Erie Elevation	Discharge	Difference.	Percent Variation from Mean.
79 P	573.01	221,200 214,400	6800	1.561'
30 I	572.64	212,600 200,700	11800	2.835'
70 J	572.52	208,500 207,600	900	216'
~~28~~ ~~116~~	~~572.50~~	~~215,400~~ ~~193,000~~	~~21500~~	~~5.32~~
~~19~~ 121	~~572.36~~	~~208,000~~ ~~196,600~~	11300	~~2.810~~
6 36	572.03	195,800 193,500	2300	592'
7 12	571.96	195,000 195,000	000	000'
67 13	571.79	191,700 191,300	400	104'
73 10	571.74	192,400 188,500	3900	1.023'
69 45	571.66	193,500 189,000	4500	1.178'
64 24	571.65	190,000 188,700	1300	343'
42 41	571.61	189,700 184,900	4800	1.280'
~~119~~ ~~48~~	~~571.58~~	~~186,100~~ ~~180,500~~	~~5600~~	~~1.537'~~
~~114~~ 5	~~571.43~~	~~181,000~~ ~~180,600~~	~~400~~	~~111'~~
55 71 ~~90~~	571.44	185,700 184,900 ~~178,200~~	7100 2800 ~~7500~~	1.946 767 ~~1.989~~
56 40	571.41	182,200 180,200	2000	552'
~~120~~ ~~120~~ ~~95~~	~~571.38~~	~~181,000~~ ~~177,700~~ ~~177,100~~	~~3300~~ ~~1300~~ ~~3900~~	~~1.088~~ ~~428~~ ~~1.285~~
86 93	~~571.32~~	~~173,000~~ ~~165,700~~	~~7300~~	~~4.217'~~
~~99~~ ~~98~~	~~571.24~~	~~149,000~~ ~~137,400~~	~~500~~	~~1.137'~~
		4,674,900	81,500	
		~~4,618,300~~	~~196,300~~	
		~~190,330'~~	~~3700~~ ~~3,710~~	

94,787 Aver. variation from mean discharge of the mean discharge. 1,729 = 0.883%

Williams Ex 34 *Table III (a)*
Sheet 1

Chicago Sanitary District
Niagara Discharge Observations
Showing Variation of Q at Bridge Section For
Same Elevation of Lake Erie by Buffalo Gage

Nos	Erie Elevation	Discharge C.F.S.	Difference	Percent Variation from Mean
71'	573.69	234300		
84	69	234500	200	0.043
64'	573.54	228470	830	0.202
60'	54	230400	7370	1.632
58'	54	222100	6130	1.320
3'	54	235600	6300	1.833
			5200	1.116
			13300	2.950
46'	573.39	227050	1770	0.388
41'	39	226620	4700	1.025
70'	39	231750	7700	1.669
111'	39	234750	2930	0.636
			5830	1.280
			3000	0.644
65'	573.30	223360		
67'	30	230220	6840	1.510
42'	573.28	219030		
30'	28	219980	950	0.216
66'	573.27	220520		
116'	27	225050	4530	1.017
57'	573.23	220590		
68'	23	222770	2180	0.492
72'	573.21	221470		
98'	21	224840	3370	0.755
62'	573.20	226780	6370	1.425
91'	20	220410	1090	0.240
101'	20	227870	3960	0.880
102'	20	222020	7460	1.665
			2410	0.544
			5050	1.121
97'	573.18	226680	6310	1.413
107'	18	220370	7970	1.788
108'	18	218710	1660	0.370
99'	573.15	221770		
100'	15	226800	5030	1.121
2'	573.12	225850		
85'	12	222880	2970	0.668
74'	573.10	222480		
96'	10	221010	1470	0.332
78'	573.08	215200	6750	1.540
84'	08	221950	9810	2.229
93'	08	225010	4120	1.850
103'	08	223320	3060	0.686
			1370	0.308
			1690	0.377
58'	573.07	217380		
109'	07	221310	3930	0.895
79	573.01	221200		
p	01	214400	6800	1.581

* Indicates 1907-1908

Williams Ex. 34. Table III a
Sheet 2

Chicago Sanitary District.
Niagara Discharge Observations
Showing Variation of Q at Bridge Section for Same Elevation of Lake Erie by Buffalo Gage.

No.	Erie Elevation	Discharge C.F.S.	Difference	Percent Variation from Mean
87	573.00	218800	3920	1.335
37	.00	224720	3540	0.602
75*	.00	222340	2810	0.630
83*	.00	221610	460	0.105
92*	00	219340	2100	0.482
95*	00	216700	2380	0.532
			3170	0.697
			6360	1.440
			8020	1.820
			730	0.164
			4000	0.908
			5640	1.284
			3270	0.744
			4910	1.121
			1640	0.377
1*	57298	224070		
110*	98	223180	1110	0.248
42*	57291	218670		
77*	91	213930	4740	1.095
36*	57287	213380		
88*	87	208520	4860	1.152
53*	57285	206410		
89*	85	198760	7650	1.801
35*	57284	216660		
87*	84	213180	3540	0.824
23*	57282	213770		
81	82	212300	1430	0.333
39*	57281	213230		
7	81	211600	1570	0.367
90*	57272	213990		
122	72	213300	310	0.073
105*	57267	212960		
C	67	211900	1040	0.244
24*	57264	210540	1960	0.463
30	.64	212500	9840	2.360
7	64	200700	11800	2.855
7*	57261	211320		
48	61	209600	1720	0.408
3*	57257	216140	3590	0.860
12*	.57	205550	13040	3.125
4	.57	208100	9450	0.847
10*	57254	209230		
14*	54	207120	2110	0.506
70	57252	208500		
J	.52	207600	900	0.216
16*	57248	208220		
19*	48	208370	150	0.036
5*	57242	202510		
8	42	206200	3690	0.904

*Indicates 1907-1908.

Williams Ex. 34 Chicago Sanitary District. Table III
Niagara Discharge Observations Sheet 3
Showing Variation of Q at Bridge Section For
Same Elevation of Lake Erie by Buffalo Gage.

Nos	Erie Elevation	Discharge C.F.S.	Difference	Percent Variation from Mean
31*	57240	211080		
d	40	201600	9480	2.299
6*	57239	202870	7350	1.780
32*	39	210220	3230	0790
b	39	206100	4120	0990
28*	57238	208650	1130	0270
33*	38	209780	350	0.084
19	38	208300	1480	0.354
13*	57235	198900	5320	1.320
21*	35	204220	8000	1.971
18	35	206900	2680	0652
30*	572.32	208330		
47	32	201000	7330	1.791
6	572.03	195800		
35	03	193500	2300	0591
7	57196	195000		
12	96	195000	000	0.000
13	571.79	191300		
67	.79	191700	400	0104
10	571.74	188500		
73	.74	192400	3900	1024
21	571.73	187400		
29	.73	188800	1400	0372
27	57166	188000	1000	0265
45	66	189000	5500	1.442
68	66	193500	4500	1175
24	57165	186700		
66	65	190000	1300	0343
41	57161	184900		
42	61	189700	4800	1.280
71	57144	182900		
56	44	185700	2800	0760
26	57141	182200		
40	41	180200	2000	0552
		23,604,330		
		204,385	4,151	

* Indicates 1907-1908 2,076 Aver. variation from Mean = 1.016 % of the mean discharge

Williams Ex. 34

Table IX

Chicago Sanitary District.
Niagara Discharge Observations
Showing Variations of Q at Open Section
For Same Elevation of Lake Erie by Buffalo Gage

N° Observation	Erie Elevation.	Discharge	Difference	Percent Variation from Mean
92	573.04	218,500		
108	.04	213,100	5400	1.25
64	572.89	216,400		
95	.89	215,200	1200	.278
83	.41	216,600		
98	.41	203,900	2700	.658
103	.28	200,700		
120	.28	199,600	1100	.275
6	.22	203,600		
121	.22	200,200	3400	.842
21	571.92	191,600		
28	.92	187,200	4400	1.162
5	.87	198,100		
20	.87	190,300	7800	2.007
27	.83	186,400		
86	.83	186,200	200	.054
14	.79	188,400		
16	.79	185,800	2600	.695
7	.77	189,900		
26	.77	188,800	1100	.290
80	.75	190,200		
15	.75	185,200	5000	1.33
19	.75	185,000	200	.054
10	.75	184,300	700	.190
85	.73	189,000	5700	1.58
12	.73	188,200	800	.212
77	.72	191,000		
25	.72	186,000	5000	1.335
53	.63	190,400		
13	.63	185,600	4800	1.276
42	.60	186,600		
22	.60	183,300	3300	.892
56	.57	183,400		
30	.57	183,400	000	.000
76	.56	188,400		
67	.56	184,200	4200	1.126
46	.53	183,200		
33	.53	181,600	1600	.438
53	.49	185,700		
18	.49	180,600	5100	1.392
45	.48	182,500		
69	.48	181,700	800	.220
78	.48	185,500		
84	.45	182,100	3400	.915
74	.43	182,200		
24	.43	178,100	4100	1.138
48	.42	183,100		
36	.42	181,600	1500	.411
52	.35	183,300		
41	.35	181,600	1700	.465
44	.33	180,200		
23	.33	176,000	4200	1.179
49	.32	179,600		
39	.28	176,700	2900	.814
		14,225,200	85900	
		189,356	2962	

1481 Aver. variation from Mean = 0.78 or 1% of the mean discharge

Williams Ex. 34. Table I

Chicago Sanitary District
St. Lawrence Discharge Observations.
Lake Ontario at Sarnia Elevation
Showing Variation in Q.

No Observations	Ontario Elev Ogdensburg	Discharge	Difference	Percent * Variation from Mean
75	245.09	249700		
78	.09	246100	3600	0.726
88	.06	253100		
61	.08	250700	2400	.476
85	.05	251500		
84	.05	251400	100	.020
82	.01	251900		
95	.01	250700	1200	.239
80	.01	249800	900	.179
05	.00	251100	2100	.419
63	.00	247300	3800	.702
07	244.99	251200		
86	.99	251700	900	.179
50	.97	252100		
68	.97	250400	1700	.339
64	.97	249400	1000	.200
92	.97	249300	100	.020
90	.94	250700	2800	.557
49	.94	249900	1800	.360
71	.94	249700	200	.040
96	.94	249700	0	.000
89	.93	251200	2000	.400
41	.93	250800	400	.080
48	.93	249000	1800	.360
72	.93	248800	200	.040
87	.92	248500	2400	.480
54	.92	248100	2400	.485
45	.92	245100	1000	.203
79	.91	250500	3400	.683
43	.91	248000	2500	.502
83	.90	251100		
42	.90	246900	4200	.844
70	.88	250000		
47	.88	249200	800	.160
77	.87	248900		
74	.87	245400	3500	.708
73	.84	249800		
60	.84	247700	2100	.424
76	.84	246000	1700	.342
55	.80	249800	2800	.566
58	.80	244.800	3700	.751
29	.04	221700		
31	.04	219400	2300	.522
12	243.94	219400		
6	.94	218300	1100	.251
10	.90	217700		
25	.90	215800	1900	.438
35	.91	218500		
30	.91	216700	1800	.413
11	.90	216500		
37	.90	215300	900	.209
		12398500	64500	
		243108	1792	

896 Aver. variation from Mean = 0.37 of 1% of the mean discharge

* Taken in pairs

Williams Ex. 34

Table VI

Chicago Sanitary District
St. Clair River Observations.

Discharges measured at Gorge and Dry Dock Sections for similar Stages of Lakes Huron and St. Clair.

No.	Date	Huron	St. Clair	Gorge	Dry Dock
103	1910-6-23	580.35	575.67	193600	
104	6-23	.43	.66	192530	
93	6-18	.43	.67	191410	
101	6-20	.40	.66	190620	
95	6-18	.41	.67	190390	
97	6-18	.38	.67	189080	
113	7-1	.30	.59	188760	
102	6-20	.35	.66	188320	
84	6-18	.43	.67	187030	
106	6-30	.27	.66	186940	
100	6-20	.36	.66	186740	
105	6-29	.31	.66	186710	
112	7-1	.30	.66	186580	
92	6-17	.33	.66	186280	
91	6-17	.32	.67	185860	
108	7-30	.28	.63	185770	
96	6-18	.31	.66	185620	
107	7-30	.28	.67	185200	
115	7-1	.30	.67	185090	
99	6-20	.33	.66	184600	
110	6-30	.28	.66	184400	
111	7-1	.32	.64	184330	
114	7-1	.22	.64	183560	
109	6-30	.28	.66	182940	
98	6-20	.28	.66	179840	
Mean		580.338	575.661	186836	
296	1910-6-24	580.46	575.66		199060
287	6-24	.41	.67		195380
285	6-24	.42	.66		193480
304	6-28	.30	.64		192300
280	6-21	.30	.64		192230
284	6-23	.43	.63		190240
307	6-29	.33	.64		189460
281	6-21	.41	.66		189260
283	6-23	.41	.66		188200
297	6-27	.30	.66		187580
279	6-21	.34	.63		187360
291	6-22	.27	.65		186230
301	6-27	.32	.63		185900
303	6-27	.28	.64		184860
318	7-2	.26	.64		183280
290	6-22	.29	.63		182870
Mean		580.378	575.659		189393
67	1910-5-18	580.41	.57	190920	
119	7-3	.27	.64	188740	
63	5-18	.43	.59	188070	
82	5-28	.34	.59	186610	
116	7-3	.28	.64	186240	
118	7-3	.26	.64	183960	
117	7-3	.28	.66	183010	
Mean		580.280	.616	186516	
300	1910-6-25	.32	.68		193080
289	6-25	.37	.67		186670
311	7-22	.23	.67		186900
310	7-21	.16	.62		178570
Mean		.280	.648		186280

Williams Ex. 34. Table VI (con)

Chicago Sanitary District
St. Clair River Observations.

Discharges measured at Gorge and Dry Dock Sections for similar Stages of Lakes Huron and St. Clair.

No.	Date	Huron	St. Clair	Gorge	Dry Dock
314	1910-8-2	580.31	575.62		187660
311	7-27	.25	.62		186900
308	7-9	.26	.63		185980
313	7-23	.29	.62		185980
312	7-23	.21	.60		185380
315	8-2	.29	.62		185120
307	7-9	.19	.64		181460
310	7-21	.16	.62		178520
Mean		580.247	575.624		183875
120	1910-7-3	.33	.65	190280	
121	7-3	.36	.65	189120	
122	7-3	.25	.65	184910	
		.313	.650	188103	
44	1909-11-6	580.00	575.09	183700	
42	11-6	.01	.08	181000	
43	11-6	579.97	.09	180800	
45	11-6	.97	575.10	180600	
Mean		579.988	575.090	181525	
09-3	1909-11-16	579.92	5.17		187600
09-6	11-19	9.88	5.03		183800
09-22	11-30	9.82	5.12		178700
09-23	11-30	9.80	5.11		178700
09-5	11-19	9.78	5.10		176600
09-21	11-30	9.79	5.12		176100
09-4	11-16	9.56	5.13		171000
Mean		579.807	5.111		178929

Williams Ex. 34. Chicago Sanitary District Table VII

St. Clair River Observations

Comparison of Discharge at Gorge and Dry Dock Sections in 1908-9 and 10 for similar stages of Lakes Huron and St. Clair

Increment due 1 foot Huron Change 36000 c.f.s

Increment due 1 foot St. Clair Change 12000 c.f.s

BY GROUPS

No. Obs.	Huron Elevation	St. Clair Elevation	Observed Gorge Discharge c.f.s.	Observed Dry Dock Discharge c.f.s.	Correction to Dry Dock Sect.	Corrected Dry Dock	Difference c.f.s.
25 10	580.332 0.378	573.661 3.639	186836	189393	-1404-24 = -1428	187965	-1109
7 4	580.280 0.280	573.616 3.648	186316	186280	-288+384 = +96	186376	+140
8 3	580.310 0.242	573.630 3.624	188103	183879	+2358-312 = +2244	186119	+1984
4 1	579.988 5.601	573.090 3.111	181525	178929	+6516+252 =6768	185697	-4172
		Arithmetic mean difference					1851

BY SINGLE OBSERVATIONS

Obs.	Huron Elevation	St. Clair Elevation	Observed Gorge Discharge c.f.s.	Observed Dry Dock Discharge c.f.s.	Correction to Dry Dock	Corrected Dry Dock Discharge	Difference c.f.s.
1	580.40 Jun 40	573.66 573.63	190620	192300	0-120 =-120	192180	-1560
2	580.30 0.30	573.63 3.63	188760	188380	0	188380	+380
3	580.29 0.29	573.67 3.67	183860	184860	0	184860	+1000
4	580.28 0.29	573.66 3.63	184400	182870	-360-120 =-480	182390	+2010
5	580.43 0.43	573.66 3.63	192530	190240	0-120 =-120	190120	+2410
6	580.27 0.27	573.64 3.63	188780	188250	0+120 =+120	188330	+450

Table VIII

Chicago Sanitary District
Niagara River

Comparison of Gagings at Bridge and Open Sections, for same Stages of Lake Erie by Buffalo Gage.

Bridge Section		Open Section		Difference		Diff. %	
No.	Discharge	No.	Discharge	+	−	+	−
			I-1899 only.				
110	176200	69	174400	1800		1.03	
109	178600	50	179400		800		0.45
108	176400	49	179600		3200		1.78
101	177500	75	181900		4400		2.42
~~97~~	~~177100~~	~~28~~	~~176000~~				
~~100~~	~~179700~~	~~44~~	~~180200~~				
~~102~~	~~181000~~		~~178100~~	~~1167~~		~~0.66~~	
	179267						
113	174900	52	183500		8600		4.69
~~91~~	~~178600~~	~~37~~	~~181400~~		~~2800~~		~~1.54~~
~~114~~	~~181000~~	~~73~~	~~185600~~				
		~~54~~	~~182100~~				
			~~183800~~		~~2800~~		~~1.52~~
~~119~~	~~185200~~	~~6~~	~~203600~~		~~18400~~		~~9.94~~
			Mean	~~1484~~	~~5867~~	~~0.81~~	~~3.66~~
			Algebraic Mean	-166	~~-4382~~		

Williams Ex. 34. Chicago Sanitary District Table IX
Niagara River

Comparison of Gagings at Bridge and Open Sections, for some stages of Lake Erie by Buffalo Gage

Bridge Section		Open Section		Difference		Diff %	
No.	Discharge	No.	Discharge	+	−	+	−
		II 1898-1899					
26	182200						
40	180200						
Mean	181200	51	185000		3800		2.06
22	181900	56	181600	300		0.17	
		53	178100				
72	183500	74	182200				
Mean	183500		180150	3350		1.86	
56	185700	57	181400	4300		2.37	
		75	183900				
5	180600	64	182100				
Mean	180600		183000		2400		1.31
		45	182900				
23	184800	60	181700				
Mean	184800		182300	2500		1.35	
		46	183200				
54	186200	33	181400				
Mean	186200		181800	4400		2.37	
		67	184200				
77	186800	76	188400				
Mean	186800		186300	500		0.27	
		38	183400				
32	188300	36	185400				
Mean	188300		184400	3900		2.07	
		22	183300				
59	188000	42	186600				
Mean	188000		184950	3050		1.65	
78	188100	13	183600	4500		2.44	
11	190400	86	183200	7200		3.78	
24	188700						
86	190800						
Mean	189350	17	182500	6850		3.78	
27	188000						
45	189000						
68	189200						
Mean	190067	54	186300	3767		2.00	
46	192200	61	184700	7500		4.06	
12	189100	9	184700	4400		2.38	
		25	186000				
28	188800	77	191800				
Mean	188800		188900	00		0.00	
21	187400	12	186200				
29	192800	65	189000				
Mean	190100		186600		500		0.27
17	190400	10	182300				
		18	185200				
		19	185000				
		80	190200				
Mean	190400		186175	4225		2.27	
18	191700	7	189900				
		66	184800				
Mean	191100		189350	1750		0.92	
73	191300	14	186200				
67	191700	16	186800				
Mean	191500		187100	4401		2.35	
34	186500	1	191300		5000		2.32
82	193000	87	186200				
		86	186200				
Mean	189600		186300	4700		2.60	
65	191700	5	191700				
		20	190300				
Mean	191700		190800	2900		1.49	
20	193600	78	192500	1500		0.67	
			Mean	3445	2626	1.86	1.41
			*Algebraic Mean			1.26	

Williams Ex. 34 Table X

Chicago Sanitary District
Niagara River

Comparison of Gagings at Bridge and Open Sections, for same Stages of Lake Erie by Buffalo Gage

Bridge Section		Open Section		Difference		Diff. %	
No.	Discharge	No.	Discharge	+	−	+	−
		III	1898-1900				
9	203700	106	195800				
		111	194400	8600		4.41	
			193100				
47	201000	97	201600		600		0.30
1	202400	112	200700	1700		0.85	
18	206900	116	201300	5600		2.70	
19	208300	109	199300	9000		4.50	
6	206100	118	201600	4500		2.24	
79	208300	110	203200				
J	207600						
	206030			4830		2.38	
82	218000	102	203900	9100		4.42	
0	207900	105	205000	2300		1.12	
			Mean	5706	600	2.84	0.30
			Algebraic Mean			249	

		IV	1899-1900				
~~119~~	~~193200~~	~~121~~	~~200200~~		~~13000~~		~~7.50~~
121	195600	116	201300		5700		2.89
124	212500	91	215900		3400		1.50
			Mean		~~4350~~ 4533		~~2.70~~ 2.97
			Algebraic Mean				~~2.97~~ 2.81

Williams Ex. 34

Chicago Sanitary District

Q for Niagara River, Bridge Section

(H=571, Q=175,000, A=21900)

Table XI

Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.	Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.	Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.
1900	Jan.	571.67	197,675	1901	Jan.	571.99	199,140	1902	Jan.	571.41	194,200
	Feb.	571.67	197,675		Feb.	571.99	199,140		Feb.	571.41	194,200
	March	571.67	197,675		March	571.99	199,140		March	571.41	194,200
	April	571.67	197,675		April	571.99	199,140		April	571.41	194,200
	May	571.67	197,675		May	571.99	199,140		May	571.41	194,200
	June	571.67	197,675		June	571.99	199,140		June	571.41	194,200
	July	571.67	197,675		July	571.99	199,140		July	571.41	194,200
	Aug.	571.67	197,675		Aug.	571.99	199,140		Aug.	571.41	194,200
	Sept.	571.67	197,675		Sept.	571.99	199,140		Sept.	571.41	194,200
	Oct.	571.67	197,675		Oct.	571.99	199,140		Oct.	571.41	194,200
	Nov.	571.67	197,675		Nov.	571.99	199,140		Nov.	571.41	194,200
	Dec.	571.67	197,675		Dec.	571.99	199,140		Dec.	571.41	194,200
		572.01	197,090			572.42	206,000			572.32	208,300
1903	Jan.	571.80	195,675	1904	Jan.	571.00	178,315	1905	Jan.	571.74	191,233
	Feb.	571.80	195,675		Feb.	571.00	178,315		Feb.	571.74	191,233
	March	571.80	195,675		March	571.00	178,315		March	571.74	191,233
	April	571.80	195,675		April	571.00	178,315		April	571.74	191,233
	May	571.80	195,675		May	571.00	178,315		May	571.74	191,233
	June	571.80	195,675		June	571.00	178,315		June	571.74	191,233
	July	571.80	195,675		July	571.00	178,315		July	571.74	191,233
	Aug.	571.80	195,675		Aug.	571.00	178,315		Aug.	571.74	191,233
	Sept.	571.80	195,675		Sept.	571.00	178,315		Sept.	571.74	191,233
	Oct.	571.80	195,675		Oct.	571.00	178,315		Oct.	571.74	191,233
	Nov.	571.80	195,675		Nov.	571.00	178,315		Nov.	571.74	191,233
	Dec.	571.80	195,675		Dec.	571.00	178,315		Dec.	571.74	191,233
		571.90	194,780			572.33	204,220			572.33	204,220

Mean Q, 1900 to 1904 = 198,068 c.f.s.

Mean Q, 1900 to 1907 = 201,436 c.f.s.

Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.	Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.	Date Year	Date Month	Gage Height Buffalo	Discharge C.F.S.
1906	Jan.	572.33	204,125	1907	Jan.	572.20	202,465	1908	Jan.	572.80	214,365
	Feb.	572.33	204,125		Feb.	572.20	202,465		Feb.	572.80	214,365
	March	572.33	204,125		March	572.20	202,465		March	572.80	214,365
	April	572.33	204,125		April	572.20	202,465		April	572.80	214,365
	May	572.33	204,125		May	572.20	202,465		May	572.80	214,365
	June	572.33	204,125		June	572.20	202,465		June	572.80	214,365
	July	572.33	204,125		July	572.20	202,465		July	572.80	214,365
	Aug.	572.33	204,125		Aug.	572.20	202,465		Aug.	572.80	214,365
	Sept.	572.33	204,125		Sept.	572.20	202,465		Sept.	572.80	214,365
	Oct.	572.33	204,125		Oct.	572.20	202,465		Oct.	572.80	214,365
	Nov.	572.33	204,125		Nov.	572.20	202,465		Nov.	572.80	214,365
	Dec.	572.33	204,125		Dec.	572.20	202,465		Dec.	572.80	214,365

Williams Ex. 34. Chicago Sanitary District Table III

Q for Niagara River Open Section

H=571, Q=172600, Δ=21,840

Lake Erie Elevations from Report of International Waterways Comm. 910

Date Year	Month	Gage Height Buffalo	Discharge C.F.S.
1900	Jan.	571.67	187100
	Feb.	571.67	187100
	March	571.67	187100
	April	571.67	187100
	May	571.67	187100
	June	571.67	187100
	July	571.67	187100
	Aug.	571.67	187100
	Sept.	571.67	187100
	Oct.	571.67	187100
	Nov.	571.67	187100
	Dec.	571.67	187100
1901	Jan.	572.01	194415
	Feb.	571.91	192600
	March	571.91	192600
	April	571.91	192600
	May	571.91	192600
	June	571.91	192600
	July	571.91	192600
	Aug.	571.91	192600
	Sept.	571.91	192600
	Oct.	571.91	192600
	Nov.	571.91	192600
	Dec.	571.91	192600
1902	Jan.	571.41	187380
	Feb.	571.41	187380
	March	571.41	187380
	April	571.41	187380
	May	571.41	187380
	June	571.41	187380
	July	571.41	187380
	Aug.	571.41	187380
	Sept.	571.41	187380
	Oct.	571.41	187380
	Nov.	571.41	187380
	Dec.	571.41	187380
1903	Jan.	571.99	194020
	Feb.	571.99	194020
	March	571.99	194020
	April	571.99	194020
	May	571.99	194020
	June	571.99	194020
	July	571.99	194020
	Aug.	571.99	194020
	Sept.	571.99	194020
	Oct.	571.99	194020
	Nov.	571.99	194020
	Dec.	571.99	194020
1904	Jan.	572.42	203295
	Feb.	572.13	199800
	March	572.13	199800
	April	572.13	199800
	May	572.13	199800
	June	572.13	199800
	July	572.13	199800
	Aug.	572.13	199800
	Sept.	572.13	199800
	Oct.	572.13	199800
	Nov.	572.13	199800
	Dec.	572.13	199800
1905	Jan.	571.78	197000
	Feb.	571.78	197000
	March	571.78	197000
	April	571.78	197000
	May	571.78	197000
	June	571.78	197000
	July	571.78	197000
	Aug.	571.78	197000
	Sept.	571.78	197000
	Oct.	571.78	197000
	Nov.	571.78	197000
	Dec.	571.78	197000
1906	Jan.	571.28	193570
	Feb.	571.74	196610
	March	571.74	196610
	April	571.74	196610
	May	571.74	196610
	June	571.74	196610
	July	571.74	196610
	Aug.	571.74	196610
	Sept.	571.74	196610
	Oct.	571.74	196610
	Nov.	571.74	196610
	Dec.	571.74	196610
1907	Jan.	572.33	201470
	Feb.	572.33	201470
	March	572.33	201470
	April	572.33	201470
	May	572.33	201470
	June	572.33	201470
	July	572.33	201470
	Aug.	572.33	201470
	Sept.	572.33	201470
	Oct.	572.33	201470
	Nov.	572.33	201470
	Dec.	572.33	201470
1908	Jan.	572.28	211500
	Feb.	572.28	211500
	March	572.28	211500
	April	572.28	211500
	May	572.28	211500
	June	572.28	211500
	July	572.28	211500
	Aug.	572.28	211500
	Sept.	572.28	211500
	Oct.	572.28	211500
	Nov.	572.28	211500
	Dec.	572.28	211500

Mean Q, 1900 to 1904 = 195,390 c.f.s. Mean Q, 1900 to 1907 = 198,708 c.f.s.

Williams Ex. 34. Chicago Sanitary District Table XLII

St. Clair River Equation
1899, 1900 and 1902
By Complainant's Groups

Letter	Huron	Coordinate Elevation	Q	Coordinate Q
A	579.93		179,200	
B	580.15		183,200	
C	27		184,900	
D	34	580.39	189,100	188,380
E	41		186,300	
F	46		186,600	
G	50		194,200	
H	57		191,100	
I	61		194,200	
J	65	580.69	195,000	195,719
K	70		196,200	
L	74		197,000	
M	78		198,000	
N	82		195,600	
O	88		198,900	
P	95	580.97	201,800	202,391
Q	581.01		203,400	
R	07		206,400	
S	13		207,600	
T	21		207,800	
U	34		213,600	

$X = 24,157Y - 13,832,100$

Williams Ex. 34. Table XIV

Chicago Sanitary District.

St. Clair River Equation.
1899, 1900, 1902 and 1908
By Complainant's Groups

Letter.	Huron	Coordinate Elev.	Q	Coordinate Q
A	579.93		179,200	
B	580.15		183,200	
Z	.17		182,500	
C	.27		184,900	
D	.34		189,100	
E	.41	580.36	186,300	187482
F	.46		186,600	
G	.50		194,200	
H	.57		194,100	
K	.59		194,000	
I	.61		194,200	
J	.65	580.66	195,000	194,939
R	.70		196,200	
L	.74		197,800	
M	.78		198,800	
N	.82		195,600	
O	.88		198,900	
P	.95		201,800	
Q	581.01	580.94	203,400	201775
R	.07		204,400	
S	.13		207,600	
T	.21		207,800	
U	.34		211,600	

X = 24,643Y - 14,114,330

Williams Ex. 34 *Table XV*

Chicago Sanitary District
St. Clair River Equation.
1899, 1900, 1901, 1902 and 1908
By Complainant's Groups

Letter	Huron	Coordinate Elevation.	Q Corr. Value 1901.	Coordinate Q	Observed Q	Coordinate Observed Q
A	579.93		179,200		179,200	
B	580.15		183,200		183,200	
Z	.17		182,500		182,500	
C	.27		184,900		184,900	
D	.34	580.388	189,100	188,108	189,100	188,731
E	.41	580.412	186,300		186,300	
F	.46		186,600		186,600	
G	.50		194,200		194,200	
H	.57		191,100		191,100	
α	.59		191,000		191,000	
I	.61		194,200		194,200	
J	.65	580.703	195,000	195,826	195,000	196,907
K	.70		196,200		196,200	
V	.69	580.709	196,200		202,800	
L	.74		197,000		197,000	
M	.78		198,000		198,000	
N	.82		195,600		195,600	
O	.88		198,900		198,900	
W	.88		201,300		202,700	
P	.95	580.956	201,800	202,000	201,800	204,300
X	.98	580.974	202,500		209,000	
Q	581.01		203,400		203,400	
R	.07		206,400		206,400	
S	.13		207,600		207,600	
Y	.16		203,700		213,400	
T	.21		207,800		207,800	
U	.34		213,600		213,600	

$X = 24,438y - 14,007,000$ Corrected values of 1901.

$X' = 28,059y - 16,097,050$ Measured values of 1901.

Williams Ex 34 Table XVI

Chicago Sanitary District.

Weighted Elevations, and Differences

For Lakes Huron and Erie During Discharge Measurements

Monthly Mean Elevation Used

1899-1908 inclusive

Year	Mo.	Huron Elevation	Erie Elevation	Diff	No. Gagings	Weighted Difference	Mean Diff.	Weighted Huron Elevation	Weighted Erie Elevation
1899	May	580.40	572.44	7.96	10	79.60		5804.00	5724.40
	June	0.79	2.56	8.23	13	106.99		7550.27	7443.28
	July	1.08	2.46	8.62	16	137.92		9297.28	9159.36
	Aug.	0.99	2.21	8.78	15	131.70		8714.85	8583.15
	Sept	0.79	1.85	8.94	7	62.58		4005.53	4002.95
	Oct.	0.33	1.61	8.77	14	122.78		8125.32	8002.54
	Nov.	0.24	1.62	8.62	16	137.92		9283.84	9145.92
					91	779.49	8.57	52841.09 580.671	52061.60 572.105
1900	June	580.30	572.47	7.83	7	54.81		4062.10	4007.29
	July	0.55	2.34	8.21	13	106.73		7547.15	7440.42
	Aug.	0.64	2.31	8.33	9	74.97		5225.76	5150.79
	Sept.	0.72	1.99	8.73	10	87.30		5807.20	5719.90
	Nov.	0.66	1.49	9.17	7	64.19		4064.62	4000.43
	Dec.	0.46	1.45	9.01	19	171.19		11028.74	10857.55
					65	559.19	8.60	37735.57 580.547	37176.38 571.944
1901	May	580.81	571.31	9.50	16	152.00		9292.96	9140.96
	June	0.91	1.72	9.19	20	183.80		11618.20	11434.40
					36	335.80	9.33	20911.16 580.866	20575.36 571.538
1902	Aug.	580.83	572.72	8.11	18	145.98		10454.94	10308.96
	Sept	0.51	2.38	8.13	30	243.90		17415.30	17171.40
					48	389.88	8.12	27870.24 580.630	27480.36 572.508
1908	Nov	580.46	571.71	8.75	12	105.00		6965.52	6860.52
	Dec.	0.23	1.42	8.81	3	26.43		1740.09	1714.26
					15	131.43	8.76	8706.21 580.414	8574.78 571.652
Totals Means		580.62	572.00	8.62	255	2195.79	8.61	148004.27 580.644	145808.48 572.093
Totals, Means Omitting Nov		580.59	572.06	8.53	219	1835.79	8.49	127153.11 580.608	125293.32 572.115

Williams Ex. 34. Table XVII

Chicago Sanitary District
Weighted Elevations and Differences
For Lakes Huron and St. Clair During Discharge Measurements
Monthly Mean Elevations Used.
1899-1908 Inclusive

Year	Mo.	Huron Elevation	St. Clair Elevation	Diff	No. Gagings	Weighted Difference	Mean Diff.	Weighted Huron Elevation	Weighted St. Clair Elevation
1899	May	580.40	575.13	527	10	52.70		5804.00	5751.30
	June	0.79	5.40	539	13	70.07		7550.27	7480.20
	July	1.08	5.57	551	16	88.16		9297.28	9209.12
	Aug.	0.99	5.51	548	15	82.20		8714.85	8632.65
	Sept.	0.79	5.20	559	7	39.13		4065.33	4026.40
	Oct.	0.38	4.90	548	14	76.72		8125.32	8048.60
	Nov.	0.24	4.77	547	16	87.52		9283.84	9196.32
					91	496.50	546	52784.09 580.611	52344.59 575.215
1900	June	580.30	575.21	509	7	35.63		4062.10	4026.47
	July	0.55	5.29	526	13	68.38		7547.15	7478.77
	Aug.	0.64	5.34	530	9	47.70		5225.76	5178.06
	Sept.	0.72	5.22	550	10	55.00		5807.20	5752.20
	Nov.	0.66	5.07	559	7	39.13		4064.62	4025.49
	Dec.	0.46	4.94	552	19	104.88		11028.74	10923.86
					65	350.72	540	37735.57 580.547	37384.85 575.152
1901	May	580.81	574.33	648	16	103.68		9292.96	9189.28
	June	0.91	5.09	582	20	116.40		11618.20	11501.80
					36	220.08	611	20911.16 580.866	20691.08 574.752
1902	Aug.	580.83	575.62	521	18	93.78		10454.94	10361.16
	Sept.	0.51	5.34	517	30	156.10		17415.30	17260.20
					48	249.88	518	27870.24 580.63	27620.36 575.445
1908	Nov.	580.46	575.23	523	12	62.76		6965.52	6902.76
	Dec.	0.23	4.98	525	3	15.75		1740.69	1724.94
					15	78.51	523	8706.21 580.414	8627.70 575.180
Totals Means		580.62	575.17	545	235	1394.67	547	140066.27 580.644	139671.60 578.713
Totals Means omitting 1901		580.59	575.22	537	219	1174.61	536	127533.11 580.606	127158.50 578.244

Williams Ex. 34. *Table XVIII*

Chicago Sanitary District

Differences in Elevation between

Huron - St. Clair (Open Season)
St. Clair - Erie Apr. - Nov. (incl.)
Huron - Erie

Year	Elevation Huron	Huron St. Clair	Elevation St. Clair	St. Clair Erie	Elevation Erie	Huron Erie
1860	582.70	6.32	576.26	2.55	573.71	9.07
1	2.92	5.09	7.03	3.05	3.98	8.94
2	2.79	5.51	7.28	3.36	3.93	8.86
3	2.18	5.48	6.70	3.26	3.44	8.74
4	1.58	5.10	6.48	3.43	3.05	8.53
5	1.38	6.38	6.20	3.44	2.76	8.82
	582.305	5.65	576.650	3.18	573.478	8.83
1866	581.20	5.00	576.20	3.33	572.87	8.33
7	1.65	5.28	6.37	3.51	2.86	8.79
8	1.09	5.07	6.02	3.39	2.63	8.46
9	1.34	5.20	6.14	3.15	2.99	8.35
1870	2.26	5.35	6.91	3.43	3.48	8.78
1	2.10	6.56	6.56	3.61	2.94	9.18
	581.607	5.84	576.365	3.40	572.962	8.84
1872	580.79	5.36	575.43	3.51	571.92	8.87
3	1.68	5.60	6.08	3.19	2.87	8.79
4	1.84	5.71	6.13	3.09	3.04	8.80
5	1.93	6.05	5.88	3.32	2.56	9.37
6	3.11	5.98	7.13	3.08	4.05	9.03
7	2.50	6.37	6.13	3.12	3.01	9.49
	581.971	5.84	576.187	3.22	572.908	9.06
1878	582.31	5.76	576.56	3.10	573.46	8.85
9	1.35	5.55	5.80	3.17	2.63	8.72
1880	1.70	5.55	6.15	3.22	2.93	8.77
1	2.02	5.87	6.15	3.24	2.91	9.11
2	2.39	5.52	6.87	3.17	3.70	8.69
3	2.76	5.80	6.96	3.38	3.58	9.18
	582.098	5.67	576.415	3.21	573.202	8.89
1884	583.25	5.81	576.98	3.42	573.56	9.23
5	3.05	6.10	6.95	3.51	3.64	9.41
6	3.27	6.46	6.81	3.26	3.53	9.74
7	2.54	6.00	6.54	3.07	3.47	9.07
8	2.00	6.00	6.00	3.16	2.84	9.16
9	1.38	5.79	4.99	3.09	2.60	8.88
	582.518	6.04	576.478	3.22	573.257	9.26
1860-1887	582.10	5.89	576.41	3.25	573.16	8.94

Williams Ex. 34 Table XVIII, con

Chicago Sanitary District

Differences in Elevation between Huron - St. Clair St. Clair - Erie Huron - Erie

(Open Season) Apr. - Nov. incl

Year	Elevation Huron	Huron St. Clair	Elevation St. Clair	St. Clair Erie	Elevation Erie	Huron Erie
1860-1889	582.10	3.69	576.41	3.23	573.16	8.94
1890	581.31	3.35	575.96	2.68	573.28	8.03
1	0.66	3.50	5.16	3.01	2.15	2.51
2	0.39	3.23	5.39	2.79	2.57	8.02
3	0.27	3.39	5.48	2.90	2.58	8.29
4	1.00	3.59	5.41	3.15	2.26	8.71
5	579.92	3.47	5.43	3.21	1.24	8.68
	580.72	3.42	575.30	2.95	572.35	8.37
1896	579.69	3.08	576.61	2.98	1.63	8.01
7	580.43	3.30	5.13	2.85	2.28	8.15
8	0.31	3.23	5.26	2.94	2.32	8.17
9	0.37	3.42	5.13	3.04	2.11	8.46
1900	0.46	3.33	5.13	3.01	2.12	8.46
1	0.80	6.03	4.77	3.24	1.53	8.27
	580.41	3.40	575.01	3.01	572.00	8.41
1902	580.39	3.23	575.16	2.96	572.20	8.19
3	0.59	3.42	5.17	2.98	2.19	8.40
4	1.21	3.29	5.31	2.82	2.49	8.02
5	1.51	3.42	5.33	3.13	2.20	8.51
6	1.23	3.38	5.38	3.13	2.25	8.51
7	1.16	3.39	5.38	3.14	2.24	8.53
	1.28	3.42	5.42	2.94	2.48	8.36
	580.96	3.37	5.60	2.99	2.61	8.35
1908	1.22	3.21	6.01	3.08	2.93	8.22
9	0.68	3.87	5.71	3.25	2.46	8.33
10	0.28	3.83	5.41	3.28	2.13	8.09
11	579.67	4.79	4.88	3.28	1.60	8.05
12	580.30	4.91	5.39	3.00	2.39	7.91
	80.42	4.94	5.48	3.17	2.31	8.11
1890-1901	580.70	3.40	575.30	2.98	572.32	8.38
1890-1908	580.73	3.39	575.34	2.99	572.35	8.38
1890-1910	580.70	3.34	575.36	3.01	572.35	8.35
1890-1912	580.64	3.30	575.34	3.02	572.32	8.32
1860-1908	581.57	3.38	575.99	3.14	572.85	8.72
1860-1910	581.52	3.34	575.98	3.13	572.85	8.69
1860-1912	581.46	3.31	575.95	3.13	572.80	8.66

Williams Ex. 34

Table XVIII-a
Sheet 1

Chicago Sanitary District

Differences in Elevation between Huron - St. Clair St. Clair - Erie Huron - Erie

(Closed Season Dec.-Mar. inc.)

Year	Elevation Huron	Huron St. Clair	Elevation St. Clair	St. Clair Erie	Elevation Erie	Huron Erie
1861	582.10	6.14	575.96	3.31	572.65	9.45
2	2.31	6.41	6.10	2.78	3.32	9.10
3	2.31	3.91	6.40	2.92	3.48	8.83
4	2.01	3.96	5.85	3.56	2.29	9.32
5	0.80	6.18	4.72	2.81	1.91	8.99
	581.93	6.12	575.81	3.08	572.73	9.20
1866	580.39	3.33	577.26	3.39	571.87	8.72
7	1.13	3.67	3.46	3.11	2.35	8.78
8	0.80	3.70	5.10	3.67	1.43	9.37
9	0.91	3.62	4.79	3.05	1.74	8.67
1870	1.39	3.38	6.01	3.12	2.89	8.50
1	1.80	6.07	3.79	3.34	2.45	9.35
	581.02	5.62	575.40	3.28	572.12	8.90
1872	580.81	5.60	575.21	3.75	571.46	9.35
3	0.65	5.84	4.81	3.60	1.21	9.44
4	1.82	6.48	5.34	2.95	2.39	8.83
5	1.41	6.00	3.21	3.63	1.58	9.63
6	1.79	5.88	6.10	3.29	2.81	8.98
7	2.51	6.40	6.11	3.40	2.71	9.80
	581.46	6.00	575.46	3.84	572.13	9.33
1878	582.09	6.48	575.56	2.66	572.90	9.14
9	1.48	6.29	3.19	2.64	2.55	9.93
1880	1.00	3.61	5.40	2.93	2.47	8.53
1	1.39	6.11	3.28	3.43	1.85	9.54
2	1.91	5.18	6.33	3.22	3.11	8.80
3	1.76	3.62	6.13	3.69	2.46	9.30
	581.60	5.95	575.65	3.09	572.56	9.04
1884	582.34	6.62	575.92	2.87	573.05	9.49
5	2.36	6.70	6.57	3.39	2.18	10.18
6	2.75	6.98	3.77	3.64	3.13	9.62
7	2.45	6.02	6.43	3.35	3.09	9.37
8	1.37	5.89	3.54	3.32	2.21	9.10
9	1.29	6.02	3.22	3.03	2.19	9.03
	582.12	6.21	575.91	3.26	572.64	9.48
1861-85	581.61	5.97	575.64	3.22	572.42	9.19

Williams Ex. 34 — Table XVIII c
Sheet 2

Chicago Sanitary District.

Differences in Elevation between Huron - St. Clair, St. Clair - Erie, Huron - Erie

(Closed Season Dec. - Mar. incl)

Year	Elevation Huron	Huron St. Clair	Elevation St. Clair	St. Clair Erie	Elevation Erie	Huron Erie
1861-89	581.61	5.97	575.64	3.22	572.42	9.19
1890	580.70	5.40	575.30	2.83	572.47	8.23
91	80.37	5.39	5.13	2.66	2.47	8.05
92	79.91	5.02	4.89	2.98	1.91	7.90
93	79.90	5.07	4.83	2.97	1.86	7.93
94	80.29	5.40	4.89	3.17	1.72	8.57
95	79.96	4.90	5.08	3.80	1.28	8.78
	580.22	5.43	574.79	3.05	571.74	8.48
1896	579.11	5.25	573.86	2.98	570.88	8.23
97	78.42	4.83	2.57	3.28	1.29	8.13
98	79.19	5.22	4.37	2.83	1.54	8.05
99	79.71	4.95	4.76	3.14	1.62	8.09
1900	79.89	5.36	4.53	2.98	1.55	8.34
01	80.21	5.91	4.30	3.13	1.17	9.04
	579.69	5.26	574.43	3.06	571.38	8.31
1902	579.91	5.66	574.03	3.07	570.96	8.95
03	3.84	4.79	3.05	3.12	1.93	7.98
04	80.01	5.09	4.92	3.37	1.55	8.46
05	0.37	5.62	4.75	3.30	1.45	8.92
06	0.66	6.06	4.60	2.93	1.67	9.76
07	0.67	5.37	5.10	2.63	2.47	8.20
	580.24	5.47	574.78	3.00	571.70	8.55
1908	580.34	5.39	575.15	2.73	572.42	8.12
09	0.01	5.63	4.39	2.81	1.58	8.20
10	0.07	5.73	4.60	3.05	1.55	8.78
11	79.80	5.39	4.41	2.67	1.74	8.06
12	79.30	4.92	4.86	3.61	1.25	8.03
	579.85	5.23	574.62	3.10	571.51	8.34
1890-1907	580.05	5.39	574.66	3.06	571.60	8.45
1890-1908	580.08	5.39	574.69	3.04	571.65	8.43
1890-1910	580.07	5.38	574.69	3.07	571.62	8.45
1890-1912	580.01	5.36	574.65	3.07	571.58	8.43
1861-1908	581.00	5.74	575.26	3.14	572.12	8.88
1861-1910	580.97	5.73	575.24	3.15	572.09	8.88
1861-1912	580.90	5.70	575.20	3.15	572.05	8.85

Williams Ex. 34. Table XIII

Chicago Sanitary District

Differences in Elevation
between
Huron - St Clair
St Clair - Erie
Huron - Erie
(Full Year)

Year	Elevation Huron	Huron St.Clair	Elevation St.Clair	St Clair Erie	Elevation Erie	Huron Erie
1860	582.68	6.47	576.21	2.71	573.50	9.18
1	2.66	5.93	6.73	3.15	3.58	9.08
2	2.62	5.80	6.82	3.13	3.69	8.93
3	2.15	5.56	6.59	3.19	3.40	8.75
4	581.53	5.25	6.28	3.48	2.80	8.73
5	1.29	5.54	5.75	3.31	2.44	8.85
	582.155	5.76	576.397	3.16	573.235	8.92
1866	580.96	5.00	575.96	3.38	572.58	8.38
7	1.40	5.38	6.02	3.41	2.61	8.79
8	0.91	5.20	5.71	3.48	2.23	8.68
9	1.03	5.30	5.73	3.08	2.65	8.38
1870	1.94	5.30	6.64	3.36	3.28	8.66
1	1.87	5.55	6.32	3.63	2.69	9.18
	581.351	5.29	576.003	3.39	572.673	8.68
1872	580.59	5.31	575.28	3.55	571.73	8.86
3	1.24	5.52	5.72	3.28	2.44	8.80
4	1.73	5.91	5.82	2.87	2.95	8.78
5	1.70	6.02	5.68	3.40	2.28	9.42
6	2.74	5.79	6.95	3.25	3.70	9.04
7	2.45	6.45	6.00	3.12	2.88	9.57
	581.741	5.83	575.908	3.25	572.663	9.08
1878	582.20	5.95	576.25	2.96	573.29	8.91
9	1.32	5.74	5.58	3.05	2.53	8.79
1880	1.49	5.47	6.02	3.25	2.77	8.72
1	1.87	6.00	5.87	3.26	2.61	9.26
2	2.21	5.51	6.70	3.22	3.48	8.73
3	2.49	5.86	6.63	3.36	3.27	9.22
	581.93	5.76	576.175	3.18	572.992	8.94
1884	582.70	6.08	576.62	3.28	573.34	9.36
5	2.86	6.02	6.84	3.60	3.24	9.62
6	3.08	6.62	6.46	3.12	3.34	9.74
7	2.43	6.00	6.43	3.12	3.31	9.12
8	1.78	5.95	5.83	3.22	2.61	9.17
9	1.28	5.86	5.42	3.04	2.38	8.90
	582.359	6.09	576.267	3.23	573.037	9.32
1860-1889	581.91	5.75	576.14	3.24	572.92	8.99

Williams Ex. 34 Table XIX con

Chicago Sanitary District.

Differences in Elevation between Huron - St. Clair St. Clair - Erie Huron - Erie (Full Year)

Year	Elevation Huron	Huron St. Clair	Elevation St. Clair	St. Clair Erie	Elevation Erie	Huron Erie
1860-1889	581.91	5.75	576.16	3.24	572.92	8.99
1890	581.11	5.34	575.77	2.72	573.05	8.06
1	0.54	5.45	5.09	2.94	2.15	8.39
2	0.38	5.45	4.93	2.79	2.14	8.24
3	0.37	5.47	5.10	3.01	2.09	8.48
4	0.76	5.54	5.22	3.12	2.10	8.66
5	579.85	5.73	4.60	3.43	1.17	8.66
	580.53	5.42	575.12	3.00	572.12	8.41
1896	579.53	5.16	574.37	2.98	571.39	8.14
7	580.13	5.14	4.99	3.09	1.90	8.17
8	0.28	5.22	5.06	2.92	2.14	8.14
9	0.29	5.29	5.00	3.01	1.99	8.30
1900	0.30	5.36	4.94	3.00	1.94	8.30
1	0.37	5.36	4.61	3.22	1.39	9.18
	580.18	5.36	574.83	3.04	571.79	8.39
1902	580.71	5.39	574.82	2.98	571.84	8.37
3	0.36	5.00	5.36	2.97	2.39	8.27
4	0.81	5.24	5.60	3.06	2.54	8.30
5	0.93	5.62	5.33	3.16	2.17	8.32
6	0.96	5.67	5.29	3.09	2.20	8.76
7	1.03	5.45	5.60	2.81	2.79	8.32
	580.73	5.40	575.33	3.01	572.32	8.41
1908	580.96	5.28	573.68	2.99	2.69	8.27
9	0.45	5.15	5.30	3.17	2.13	8.30
10	0.12	5.02	3.10	3.23	1.87	8.23
11	579.57	5.03	4.54	3.01	1.47	8.10
12	0.04	4.80	3.24	3.22	2.02	8.02
	580.23	5.05	575.18	3.14	572.04	8.19
1890-1907	580.48	5.39	573.09	3.01	572.08	8.40
1890-1908	580.51	5.39	573.12	3.01	572.11	8.40
1890-1910	580.48	5.35	575.13	3.03	572.10	8.38
1890-1912	580.43	5.32	575.11	3.04	572.07	8.36
1860-1908	581.36	5.60	575.76	3.15	572.61	8.75
1860-1910	581.32	5.58	575.74	3.16	572.58	8.74
1860-1912	581.26	5.53	575.73	3.10	572.35	8.71

Williams Ex. 34 *Table XI*

Chicago Sanitary District
Q for St. Clair River
(H=380. Q=177900, δ=23 820)
By Complainant's Equation

Date		Gage Height	Discharge	Date		Gage Height	Discharge	Date		Gage Height	Discharge
Year	Month	Harbor Datum	C.F.S.	Year	Month	Harbor Datum	C.F.S.	Year	Month	Harbor Datum	C.F.S.
1900	Jan.	379.74	174700	1903	Jan.	379.74	174700	1905	Jan.	380.53	200320
	Feb.		173600		Feb.		173600		Feb.		199330
	Mar.		174300		Mar.		174300		Mar.		200030
	Apr.	380	177900		Apr.	380	177900		Apr.	381	203700
	May		181000		May		181000		May		206900
	June		181000		June		181000		June		206900
	July		183000		July		183000		July		208400
	Aug.		183000		Aug.		183000		Aug.		208400
	Sept.		183000		Sept.		183000		Sept.		208400
	Oct.		183000		Oct.		183000		Oct.		208400
	Nov.		183000		Nov.		183000		Nov.		208400
	Dec.	379.72	180700		Dec.	380.53	183000		Dec.	380.36	200863
1901	Jan.	379.74	180700	1904	Jan.	379.91	179765	1906	Jan.	380.65	193320
	Feb.		179600		Feb.		179765		Feb.		193320
	Mar.		180300		Mar.		180410		Mar.		194100
	Apr.	380	183000		Apr.	380.06	182300		Apr.	381	196700
	May		186000		May		186000		May		200000
	June		186000		June		186000		June		200000
	July		187500		July		187500		July		201700
	Aug.		187500		Aug.		187500		Aug.		201700
	Sept.		187500		Sept.		187500		Sept.		201700
	Oct.		187500		Oct.		187500		Oct.		201700
	Nov.		187500		Nov.		187500		Nov.		201700
	Dec.	380.30	187500		Dec.	380.06	187500		Dec.	380.21	201700
1902	Jan.	379.91	187500	1905	Jan.	380.24	187900	1907	Jan.	380.65	193320
	Feb.		187500		Feb.		187900		Feb.		193320
	Mar.		187500		Mar.		187900		Mar.		193320
	Apr.	380	187500		Apr.	380.38	188000		Apr.	381	196700
	May		187500		May		188000		May		196700
	June		187500		June		188000		June		196700
	July		187500		July		188000		July		196700
	Aug.		187500		Aug.		188000		Aug.		196700
	Sept.		187500		Sept.		188000		Sept.		196700
	Oct.		187500		Oct.		188000		Oct.		196700
	Nov.		187500		Nov.		188000		Nov.		196700
	Dec.	380.57	187500		Dec.	380.38	188000		Dec.	380.21	196700
1903	Jan.	379.91	187500	1906	Jan.	380.38	188000	1908	Jan.	381.03	202880
	Feb.		187500		Feb.		188000		Feb.		
	Mar.		187500		Mar.		188000		Mar.		
	Apr.	380.06	187500		Apr.	380.38	188000		Apr.		
	May		187500		May		188000		May		
	June		187500		June		188000		June		
	July		187500		July		188000		July		
	Aug.		187500		Aug.		188000		Aug.		
	Sept.		187500		Sept.		188000		Sept.		
	Oct.		187500		Oct.		188000		Oct.		
	Nov.		187500		Nov.		188000		Nov.		
	Dec.	380.06	187500		Dec.	380.38	188000		Dec.		
1904	Jan.	379.91	187500	1907	Jan.	380.65	193320				
	Feb.		187500		Feb.		193320				
	Mar.		187500		Mar.		193320				
	Apr.	380	187500		Apr.	381	196700				
	May		187500		May		196700				
	June		187500		June		196700				
	July		187500		July		196700				
	Aug.		187500		Aug.		196700				
	Sept.		187500		Sept.		196700				
	Oct.		187500		Oct.		196700				
	Nov.		187500		Nov.		196700				
	Dec.	380.06	187500		Dec.	381	196700				

Mean Q 1900 to 1904 = 185,787 c.f.s. Mean Q 1900 to 1907 = 193,528 c.f.s.

Williams Ex. 34 Table XXI

Chicago Sanitary District
Relative Fluctuation of Lakes

St. Clair - Huron
Erie - Huron

Huron Elevation Decreasing

1	2	3	4	5	6	7	8	9	10	11
	Year	Huron		St. Clair		Year	Huron		Erie	
		Elevation	C. of G.	Elevation	C. of G.		Elevation	C. of G.	Elevation	C. of G.
1860-1889	1886	583.08		576.46					573.34	
	85	2.86		6.84					3.24	
	76	2.74		6.95					3.70	
	84	2.70		6.62					3.34	
	60	2.68		6.21					3.50	
	61	2.66		6.73					3.58	
	62	2.62		6.82				582.515	3.69	573.378
	83	2.49	582.472	6.63	576.546				3.27	
	77	2.45		6.00					2.88	
	87	2.43		6.43					3.31	
	82	2.21		6.70					3.48	
	78	2.20		6.25					3.29	
	63	2.15		6.59					3.40	
	70	1.94	581.907	6.64	576.162			581.907	3.28	572.920
	71	1.87		6.32					2.69	
	81	1.87		5.87					2.61	
	88	1.78		5.83					2.61	
	74	1.73		5.82					2.95	
	75	1.70		5.68					2.80	
	64	1.53		6.28					2.80	
	80	1.49		6.02					2.77	
	67	1.40	581.341	6.02	575.779			581.374	2.61	572.519
	79	1.32		5.58					2.53	
	65	1.29		5.75					2.44	
	89	1.28		5.42					2.39	
	73	1.24		5.72					2.44	
	69	1.03		5.73					2.65	
	66	0.96		5.96					2.58	
	68	0.91		5.71					2.23	
	72	0.59		5.28					1.73	
1891-1910	1907	581.05		575.60		1907	581.05		572.73	
	06	580.96		.29		06	580.96		2.26	
	08	.98		.68		08	.98		2.69	
	05	.95		.33		05	.95		2.17	
	04	.84		.60		04	.84	580.741	2.54	572.327
	1894	.76	580.741	.25	575.361	1894	.76		2.10	
	93	.57		.10		93	.47		2.09	
	91	.54		.09		91	.54		2.15	
	1909	.42		.33		1909	.42		2.13	
	03	.36	580.452	.37	575.103	1903	.36	580.448	2.39	572.076
	01	.57		574.61		1901	.57		1.39	
	1892	.38		.93		1892	.38		2.14	
	1900	.30		.54		00	.30		1.94	
	1899	.29		575.00		1899	.29		1.93	
	98	.28		.08		98	.28	580.133	2.14	571.807
	1902	.21	580.164	574.81	574.868	1902	.21		1.84	
	1897	.13		.99		1897	.13		1.96	
	1910	.12		575.14		1910	.12		1.87	
	1895	579.83		574.60		1895	579.83		1.17	
	96	.53		.37		96	.53		1.39	

1860-89	582.472	576.546	0.767			582.515	573.378	0.459			
	581.341	575.779	1.131			581.374	572.519	1.141			
	1.131	0.767		67.8%		1.141	0.859		= 75.3%		
1891-1910	580.741	575.361	0.516			580.741	572.327	0.520			
	580.164	574.868	0.377			580.133	571.807	0.608			
	0.577	0.516		89.4%		0.608	0.520		85.5%		

*Given a weight of 03

Williams Ex. 34. Table XXII

Chicago Sanitary District

Equations of Discharge of St Clair River and Increment due to Lake Huron.

From simultaneous readings of slope and discharge, Lake St Clair gauges.

1899, 1900, 1901, 1902 and 1908

1	2	3	4	5	6	7	8	9	10
No Observation	Duration St Clair	Coef G "C"		Coef G "A"		Coef G "B"		Equation	Increment
		Elev Huron	Discharge	Elev Huron	Discharge	Elev Huron	Discharge		
15	57858	581.20	180480	581.275	210347	581.151	225322	X=39473Y-2258[illegible]	39493
11	.48	0.91	180900	1.070	206535	0.714	190400	33000 Y-3018[illegible]	38018
31	.36	0.83	178800	0.99	204400	0.670	189800	39390 Y-2268[illegible]	39398
4	.31	0.96	180885	1.01	199800	0.73	187400	35387Y+2038[illegible]	35387
25	.25	0.85	179012	0.83	198000	0.68	186600	38586 Y-2219[illegible]	38586
9	.21	0.80	179111	0.895	203350	0.77	193800	32400 Y-1847[illegible]	32400
28	.16	0.58	179164	0.85	199387	0.61	186500	30918 Y+1433[illegible]	30918
6	.10	0.85	179325	0.895	203350	0.77	193300	32400 Y-1847[illegible]	32400
17	57826	0.81	179871	0.914	204650	0.64	185500	41600 Y-2394[illegible]	41600
6	.91	1.03	180450	0.92	186900	0.02	169800	18600 Y-1060[illegible]	18600
19	.86	0.82	178847	0.981	202300	0.847	191800	33300 Y-1914[illegible]	33300
11	.81	0.[illegible]	178871	0.748	204700	0.577	190300	36814 Y-2137[illegible]	36814
13	.76	0.88	179138	0.984	211400	0.819	194800	33340 Y-1922[illegible]	33340
4	.71	0.18	184178	0.33	179000	0.095	168800	22286 Y-1360[illegible]	22286
14	.66	0.11	184800	0.318	178440	57.1899	177400	64325 Y-4[illegible]	64325
								Mean of Increments 34,385	

Mean Equation:

X = 34,385 Y - 19,771,889

Williams Ex. 34

Table XXIII

Chicago Sanitary District
Equations of Discharge of St. Clair River
and Increments due to Lake St. Clair.

From simultaneous readings of stage and discharge - Lake Huron constant.
1899, 1900, 1901, 1902 and 1908

1	2	3	4	5	6	7	8	9	10
No. Pairs	Elevation Huron	C of G "C" Elev. St. Clair	C of G "C" Discharge	C of G "A" Elev. St. Clair	C of G "A" Discharge	C of G "B" Elev. St. Clair	C of G "B" Discharge	Equation	Increment
8	581.11	575.23	208840	575.44	206770	574.91	211950	$x = -9775y + 2999198$	-9775
4	1.08	5.31	207850	5.48	203200	4.86	221800	-31000 + 10991800	-31000
5	1.02	5.22	204500	.33	203000	5.14	205500	-13160 + 7770500	-13160
4	0.96	5.41	201180	.66	199500	.35	201600	-6790 + 4100600	-6790
5	0.95	5.30	205150	.54	201600	.06	208700	-14800 + 8718700	-14800
5	0.92	5.06	206280	.21	203850	4.98	207870	-16080 + 9452870	-16080
4	0.87	5.32	201150	.41	199900	5.08	204900	-14290 + 8419900	-14290
4	0.85	5.27	195625	.38	193400	4.96	202200	-20950 + 12332200	-20950
5	0.82	5.15	201680	.41	198080	.75	207650	-14580 + 8587650	-14580
7	0.81	5.29	195114	.39	196970	5.22	194180	+12890 - 8875320	+12890
4	0.79	5.12	195800	.38	191350	4.49	200850	-10600 + 6282250	-10600
4	0.70	4.98	199575	.49	198000	.48	201430	- 7580 + 4813430	- 7580
3	0.69	5.18	194533	4.81	201800	5.34	190900	-19818 + 11593380	-19818
4	0.64	5.17	197775	5.31	195450	5.035	200100	-16910 + 10185100	-16910
5	0.62	5.10	195220	4.86	197520	.26	193667	- 9707 + 5719000	- 9707
3	0.61	4.99	194867	4.61	198200	.36	188200	-18182 + 10849400	-18182
3	0.60	5.00	197800	4.86	197800	.27	196000	- 4390 + 2784935	- 4390
3	0.51	5.04	191500	4.86	194400	.139	190050	-15240 + 9807535	-15240
2	0.48	4.90	198650	4.81	194267	.16	187800	-18477 + 10815031	-18477
5	0.39	5.06	187620	5.21	185370	4.84	191000	-15216 + 9189000	-15216
4	0.32	4.98	189400	5.16	184100	4.81	194700	-30290 + 17549700	-30290

-14072 = Mean of Increment.

Mean Equation:

$X = -14,072\,Y + 9,487,163$

Williams Ex. 34. Table XXIII

Chicago Sanitary District

Equations of Discharge of St Clair River

Weighting of Increments.
in Tables XXII and XXIII

Lake Huron				Lake St. Clair.			
Elevation of St. Clair	No of Obser.	Increment	Product	Elevation of Huron	No of Obser.	Increment	Product
575.56	15	39073	586095	581 11	5	- 9775	- 48875
.46	11	35000	385000	08	4	-31000	-124000
.36	31	39390	1221090	.02	5	-13160	- 65800
.31	4	35957	141428	580.96	5	-6780	-33900
.26	25	38580	964500	95	4	-14800	-59200.
.21	9	32400	291600	.92	5	-16080	-80400
.16	28	30518	854504	.87	4	-14290	-57160
.06	4	32400	129600	.85	4	-20950	-83800
574 96	17	41600	707200	.82	5	-14560	-72900
.91	4	18600	74400	.81	7	+12890	+90230
.86	19	33300	632700	.73	4	-10600	-42400
.81	11	38814	426954	.70	4	- 7580	-30320
.76	13	33540	436020	.69	3	-19818	-59454
71	4	22880	91520	.64	4	-16910	- 67640
66	14	44325	620550	.62	5	- 9707	-48535
				.61	3	-18182	-54546
				.60	3	-4390	-13170
				.51	3	-15818	-47454
				.48	4	-18477	-73908
				.39	5	-15216	-76080
				.32	4	-30290	-121160
	209		+7563161.		90		1170,472
Weighted Mean			+36187.				-13,005

Net Increment St. Clair Change = 66⅔% of Huron Change
36187 - ⅔ × 13,005 = 27,517
St. Clair Change = 89% of Huron Change
36187 - 0.89 × 13005 = 24,613

Williams Ex. 34. Table XXV

Chicago Sanitary District
Equations of Discharge of St. Clair River
and Increments due to Lake Huron
1908 to 1910
From simultaneous readings of stage
and discharge Lake St. Clair constant

1	2	3	4	5	6	7	8	9	10
No. Observation	Duration	C of G "C"		C of G "A"		C of G "B"		Equation	Increment
	St. Clair	Elev. Huron	Discharge	Elev. Huron	Discharge	Elev. Huron	Discharge		
1	573.71	580.36	184,480	580.35	183,810	580.32	182,900	X= 33830Y-19,444,900	33830
2	.70	.36	184,310	.41	185,510	.36	183,870	29540Y-16,986,610	29540
3	.69	.36	184,310	.37	184,160	.34	183,460	27170Y-15,663,300	27170
4	.67	.36	184,140	.44	187,000	.32	182,410	25380Y-14,670,700	25380
5	.66	.36	184,140	.41	185,940	.36	183,700	24230Y-13,956,970	24230
6	.63	.36	183,960	.40	185,540	.34	183,300	22810Y-13,126,970	22810
7	.62	.36	183,790	.42	186,370	.33	182,850	21940Y-12,632,760	21940
8	.61	.36	183,790	.38	184,340	.33	182,850	21240Y-12,217,000	21240
9	.60	.37	183,960	.38	184,340	.34	183,300	20840Y-11,971,040	20840
10	.59	.37	184,140	.37	184,160	573.98	171,370	21310Y-12,327,840	21310
11	573.58	580.37	177,810	.35	183,340	.36	183,360	23100Y-13,423,200	23100
12	.57	580.37	184,140	.41	185,940	580.34	183,040	23180Y-13,423,200	23180
13	.55	580.10	184,140	.17	183,780	580.04	178,740	27510Y-15,838,640	27510
14	.54	.12	184,310	.19	183,100	579.97	178,510	28200Y-16,231,160	28200
15	.53	.12	184,310	.18	183,440	580.06	179,010	28430Y-16,373,240	28430
16	.52	.10	184,310	.15	183,940	.08	180,010	28980Y-16,691,800	28980
17	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
18	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
19	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
20	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
21	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
22	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
23	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
24	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
25	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
26	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
27	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
28	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
29	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
30	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
31	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
32	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
33	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
34	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
35	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
36	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
37	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
38	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
39	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
40	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
41	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
42	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
43	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
44	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
45	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
46	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
47	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
48	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
49	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
50	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
51	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
52	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
53	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
54	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
55	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
56	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
57	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
58	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
59	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
60	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
61	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
62	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
63	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
64	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
65	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
66	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
67	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
68	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
69	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
70	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
71	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
72	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
73	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
74	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
75	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
76	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
77	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
78	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
79	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
80	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
81	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
82	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
83	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
84	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
85	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
86	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
87	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
88	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
89	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
90	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
91	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
92	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
93	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
94	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
95	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
96	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
97	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
98	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
99	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
100	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
101	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
102	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
103	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
104	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
105	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
106	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
107	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
108	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
109	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
110	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
111	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
112	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
113	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
114	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
115	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
116	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
117	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
118	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
119	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
120	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
121	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
122	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
123	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
124	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
125	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
126	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
127	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
128	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
129	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
130	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
131	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
132	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
133	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
134	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
135	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
136	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
137	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
138	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
139	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
140	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
141	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
142	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
143	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
144	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
145	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
146	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
147	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
148	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
149	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
150	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
151	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
152	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
153	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
154	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
155	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
156	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
157	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
158	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
159	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
160	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
161	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
162	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
163	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
164	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
165	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
166	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
167	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
168	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
169	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
170	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
171	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
172	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
173	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
174	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
175	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
176	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
177	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
178	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
179	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
180	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
181	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
182	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
183	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
184	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
185	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
186	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
187	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
188	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
189	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
190	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
191	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
192	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
193	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
194	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
195	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
196	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
197	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
198	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
199	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
200	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
201	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
202	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
203	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
204	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
205	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
206	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
207	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
208	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
209	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
210	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
211	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
212	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
213	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
214	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
215	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
216	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
217	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
218	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
219	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
220	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
221	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
222	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
223	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
224	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
225	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
226	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
227	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
228	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
229	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
230	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
231	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
232	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
233	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
234	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
235	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
236	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
237	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
238	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
239	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
240	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
241	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
242	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
243	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
244	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
245	573.96	580.10	177,810	579.98	179,080	579.90	176,740	40600Y-23,419,000	40600
246	580.16	580.10	184,480	580.26	187,430	.08	180,010	40600Y-23,419,000	40600
247	573.98	580.10	184,310	.07	183,440	579.82	177,170	33280Y-19,709,100	33280
248	580.18	580.10	184,480	.28	187,740	580.10	184,250	41610Y-23,994,170	41610
249	.17	.10	184,480	.26	187,430	.10	184,080	41400Y-23,880,000	41400
250	573.96	580.10	177,

Williams Ex. 34. Table XXVI

Chicago Sanitary District
Equations of Discharge of St. Clair River
and Increments due to Lake St. Clair
1908 to 1910.

From simultaneous readings of stage
and discharge Lake Huron constant.

1	2	3	4	5	6	7	8	9	10
No. Observ. in Period	Elevation Huron	C. of G. "C" Elev. St. Clair	C. of G. "C" Discharge	C. of G. "A" Elev. St. Clair	C. of G. "A" Discharge	C. of G. "B" Elev. St. Clair	C. of G. "B" Discharge	Equation	Increment
[illegible]	580.45	575.38	195830	575.66	192480	575.24	197500	X = -11950 Y + 7 071 630	-11950
[illegible]	.45	.37	[illegible]	.50	189760	.48	191420	-9110 Y + 5 494 100	-9110
[illegible]	.41	[illegible]	[illegible]	.07	[illegible]	.37	[illegible]	[illegible] Y + 12 243 330	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.07	189080	.05	191100	[illegible] Y + 9 204 010	[illegible]
[illegible]	.37	[illegible]	190070	[illegible]	187170	[illegible]	[illegible]	[illegible] Y + 8 012 500	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	.63	.30	168190	[illegible]	[illegible]	.14	169700	-8500 Y + 5 838 [illegible]	-8500
								Mean Increment	-11230

Mean Equation:

$X = -12,230Y + 7,220,580$

Ex 34

Table XXVII

Chicago Sanitary District
Equations of Discharge of St. Clair River
Weighting of Increments
1908 to 1910.

Lake Huron				Lake St. Clair			
Elevation of St. Clair	No. of Obser.	Increment	Product	Elevation of Huron	No. of Obser.	Increment	Product
573.71	3	33830	101490	580.45	9	11950	35850
.70	3	19240	57720	.43	2	9110	18220
.68	4	27370	109480	.41	4	20940	83760
.67	11	56480	621280	.39	4	13860	55440
.66	16	60430	967000	.37	4	13330	53320
.63	17	32310	549270	.35	4	13480	53920
.64	9	24240	218160	.33	11	1805	19855
.63	7	30560	213920	.32	2	5770	11540
.62	3	41310	123930	.31	4	9610	38440
.61	3	49100	147300	.29	2	13330	26660
.59	2	25180	50360	.28	2	12250	24500
.58	8	67810	542480	.27	2	6145	12290
.56	9	56200	505800	.25	2	9005	18010
.55	7	40430	283010	.24	9	12490	112410
.54	3	50290	150870	.23	2	5380	10760
.53	3	53260	159780	.21	6	16002	96012
.52	3	21210	63630	.18	6	37430	224580
.51	3	74060	222180	.17	2	11330	22660
.50	4	16080	64320	.16	3	20960	62880
.49	5	27540	137700	.14	2	12780	25560
.48	3	27520	109560	.11	2	3900	7800
.47	2	49000	98000	.10	2	3270	6540
.46	2	29700	118800	.08	2	10360	41440
.45	2	38730	77500	.06	2	8280	33120
.44	3	39780	219450	.04	2	13700	54800
.43	7	19970	139790	.02	2	13350	53400
.42	2	40000	80000	.01	2	12250	49000
.41	2	13620	27240	.03	2	5190	10380
.40	3	41800	209400	.05	2	14600	58400
.39	3	11790	35370	.07	2	9350	37400
.38	3	32770	123080	79.98	2	10020	40080
.37	4	44160	176120	.96	2	25970	103880
.36	4	38570	154280	.94	2	19200	77200
.35	4	7500	30000	.92	2	13855	41565
.34	10	24540	245400	.90	2	21820	87280
.33	8	30250	241500	.88	2	9000	18000
.32	10	29920	299200	.86	2	18250	91250
.31	8	28020	224160	.84	2	20440	81760
.30	6	21300	127800	.82	2	8500	17000
.29	6	23640	141840				
.28	5	25390	126950				
.27	2	24200	48400				
.26	3	23150	69450				
.25	3	40000	120000				
.24	3	17500	52500				
.23	3	36500	109500				
574.97	2	17270	34540				
.96	3	21250	63750				
	241		8627060		178		210540
Weighted Mean 35797				Weighted Mean = 11817			

Net Increment - St Clair Change = 66⅔% of Huron Change
35,797 - ⅔ × 11,817 = 27919
St Clair Change = 89% of Huron Change
35,797 - .89 × 11,817 = 26280

Table XIII
Sheet 1

Chicago Sanitary District
St. Clair River.
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1899-1902

Group	Date	Lake Surfaces				Observed Discharge	Weight by Time Interval	Weighted Discharge
		Observed Huron	Observed St. Clair	Huron Mean Daily	St. Clair Mean Daily			
						C.F.S.		C.F.S.
	1899-6-7				575.42			
	8	580.91	575.36	580.78	.42	206,700	1.5	310,050
	9			.89	.42			
	10	580.92		.71	.42	205,900	2.0	411,800
	11			.71	.42			
I	12	580.58		.63	.42	194,400	1.5	291,600
	13	.68		.65	.42	193,900	1.0	193,900
	14	.84		.78	.42	194,200	1.0	194,200
	15	.96		.75	.42	202,300	1.0	202,300
	16	581.13		.81	.42	210,800	1.0	210,800
	17	.02		581.05		203,100	1.0	203,100
		580.880	575.36	580.777	575.42	201,640	10.0	201,975
	1899-7-14				575.62			
	15	581.09	575.56	581.04	.62	205,300	1.5	307,950
	16			.18	.62			
	17	.39		.18	.62	218,900	1.5	328,350
	18	.19		.18	.62	204,800	1.0	206,800
	19	.28		.07	.62	207,200	1.0	207,200
	20	.09		.08	.59	203,900	1.5	305,850
	21			.11	.62			
II	22	.22		.14		210,900	1.5	316,350
		581.21	575.56	581.115	575.616	208,830	8.0	209,080
	1899-7-23				575.62			
	24	581.14	575.56	580.98	.62	206,000	1.0	206,000
	25	.15		581.04	.62	206,800	1.0	206,800
	26	.08		.01	.62	196,700	1.0	196,700
	27	.33		.21	.62	209,300	1.0	209,300
	28	.19		.08	.62	203,300	1.0	203,300
III	29	.18		.11		208,200	1.0	208,200
		581.178	575.56	581.072	575.62	205,380	6.0	205,380
	1899-8-17				575.42			
	29	580.96	575.36	580.91	.42	206,900	1.0	206,900
	29	.98		.61	.42	204,100	1.0	204,100
	30	.87		.91	.42	199,900	1.0	199,900
IV	31	.91		.84		200,700	1.0	200,700
		580.93	575.36	580.842	575.42	202,900	4.0	202,900
	1899-10-9				574.92			
	10	580.16	574.86	580.14	.92	180,900	1.0	180,900
	11	.34		.54	.92	190,000	1.5	285,000
	12			.31	.92			
	13	.17		.21	.92	184,900	1.5	276,750
	14	.60		.61	.92	209,200	1.5	313,800
	15			.31	.92			
V	16	.03		.11	.92	180,800	1.5	270,450
	17	.70		.18	.92	198,700	1.0	198,700
	18	.51		.54	.92	194,400	1.0	194,400
	19	.61		.31		197,600	1.0	197,600
		580.415	574.86	580.304	574.92	191,950	10.0	191,760

Williams Ex 34. Table XXIII Sheet 2

Chicago Sanitary District
St. Clair River.
Discharge at Constant Stages
Sagings Weighted by Days in Periods
1899 - 1902

Group	Date	Lake Surfaces				Observed Discharge	Weight by Time Interval	Weighted Discharge
		Observed Huron	Observed St. Clair.	Huron Mean Daily	St. Clair Mean Daily			
	1899-11-21				574.72	C.F.S.		C.F.S.
	22	579.71	574.66	580.24	.72	180300	1.0	180300
	23	.97		.21	.72	195200	1.0	195200
	24	580.32		.21	.72	192900	2.0	385800
VI	25			.24	.72			
	26			.21	.72			
	27	580.26		.14	.72	186500	2.0	373000
	28	.16		.11	574.72	185400	1.0	185400
	29	.18		.01		181400	1.0	181400
		580.10	574.66	580.171	574.72	186950	8.0	187640
	1900-7-1				575.22			
	2	580.30	575.16	580.18	.22	182400	1.0	182400
	3	.34		.28	.22	182500	1.5	273750
	4			.41	.22			
VII	5	580.31		.38	.22	182200	2.0	364400
	6			.34	575.22			
	7	580.66		.41		191100	0.75	143320
	7	.54				190700	0.75	143030
		580.43	575.16	580.333	575.22	185780	6.00	184480
	1900-7-30				575.42			
	31	580.96	575.36	580.78	.42	199300	1.0	199300
	8-1	.85		.68	.42	195000	1.0	195000
	2	.69		.61	.42	189200	0.75	141900
VIII	2	.81				196400	0.75	147300
	3			.64	.42			
	4	.81		.54	.42	188200	1.50	282300
	5	.57		.61	.42	186900	1.00	186900
	6	.68		.61		192900	1.00	192900
		580.739	575.36	580.639	575.42	192560	7.00	192230
	1900-11-29				574.87			
	30	580.22	574.81	580.58	.87	182500	1.0	182500
	12-1	.48		.58	.87	196000	1.5	294900
	2			.48	.87			
IX	3	.37		.41	.87	191200	1.5	286800
	4	.48		.51	.87	196000	1.0	196000
	5	.70		.81	.87	201100	1.0	201100
	6	.48		.64	.87	190200	1.0	190200
	7	.75		.61	574.87	202400	1.0	202400
	8	.21		.38		185600	1.0	183600
		580.461	574.81	580.355	574.87	193200	9.0	193280

Williams Ex 34 *Table XIII*
Sheet 3

Chicago Sanitary District.
St. Clair River.
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1899 - 1902.

Group	Date	Lake Surfaces				Observed Discharge	Weight by Time Interval	Weighted Discharge
		Observed Huron	Observed St Clair	Huron Mean Daily	St. Clair Mean Daily			
						C.F.S.		C.F.S.
	1901-6-6				575.02			
	7	681.13	574.96	580.68	.02	203800	0.5	101900
	7	.14				211300	0.5	105650
	8	.24		.78	.02	215100	0.75	161320
	8	.11				213500	0.75	160130
	9			.79	.02			
X	10	580.92		.74	.02	207900	0.75	155930
	10	.85				202200	0.75	151650
	11	.83		.81	.02	208100	0.75	156070
	11	.62				200500	0.75	150370
	12			.78	.02			
	13	580.86		.92	575.02	206100	1.5	309150
	14	.92		.83		209100	0.5	104550
	14	.92				206600	0.5	103300
		580.958	574.96	580.794	575.02	207830	8.00	207580
	1902-9-6				575.22			
	17	580.30	575.18	580.29	.22	179000	0.5	89500
	17	.32	.16			181700	0.5	90860
	18	.45	.18	.44	.22	183500	1.0	183500
	19	.78	.21	.58	.27	194800	1.0	194800
	20	.59	.21	.42	.27	188000	1.5	282000
XI	21			.40	.22			
	22	.48	.16	.45	.22	187800	0.75	140850
	22	.48	.16			184100	0.75	138075
	23	.54	.21	.49	.27	187900	0.5	93950
	23	.63	.21			190600	0.5	95300
	24	.57	.21	.44		190800	1.0	190800
		580.811	575.185	580.459	575.239	184820	8.0	187430

Ex 34. Table XXIX

Chicago Sanitary District

St. Clair River Observations.

Elevations of Lake Surfaces and Variations from Means, during Selected Gaging Periods of 1899 to 1902 inclusive

Mean Elevations for Open Season

Lake Huron - 1890 to 1910 580.70

Lake St. Clair - 1890 to 1910 575.36

				Lake Huron		Lake St. Clair	
Gaging	Group	Days	Period	Elevation	Change from Mean	Elevation	Change from Mean
6	II	8	1899-7 $\frac{13}{22}$	581.115	+ .42	575.616	+ .26
6	III	6	1899-7 $\frac{24}{29}$	.072	+ .37	.620	+ .26
4	IV	4	1899-8 $\frac{28}{31}$	580.842	+ .14	.420	+ .06
11	X	8	1901-6 $\frac{7}{14}$	.794	+ .09	.020	- .34
8	I	10	1899-6 $\frac{8}{17}$	.777	+ .08	.420	+ .06
7	VIII	7	1900-7 $\frac{31}{6}$	.639	- .06	5.420	+ .06
8	IX	9	1900-11 $\frac{22}{3}$	.555	- .14	4.870	- .49
10	XI	8	1902-9 $\frac{17}{24}$	.439	- .26	5.239	- .12
5	VII	6	1900-7 $\frac{2}{7}$	.333	- .37	5.220	- .14
8	V	10	1899-10 $\frac{8}{18}$	.304	- .40	4.920	- .44
6	VI	8	1899-11 $\frac{12}{19}$	.171	- .53	4.720	- .64

Williams Ex 34. Table XII

Chicago Sanitary District.

St. Clair River Observations

Normal Change of Lake St. Clair from Mean of 1830 to 1910 for Gaging Periods of 1899 to 1902, assuming St. Clair Change to be 66⅔ % of Huron Change, and observed Variation from such Normal Change, and discharges corrected to Normal Stage for Increment of Lake St. Clair = -13000 c.f.s.

1	2	3	4	5	6	7	8
Group	Change from Mean				Correction due St. Clair	Discharge	
	Huron	St. Clair				Observed	Corrected to Normal Stage
	Normal	Observed	Normal	Diff			
II	+ .42	+ .26	+ .28	- .02	- 260	209060	208800
III	+ .37	+ .26	+ .25	+ .01	+ 130	205330	205480
IV	+ .14	+ .06	+ .09	- .03	- 390	202900	202510
X	+ .09	- .34	+ .06	- .40	- 5200	207500	202300
I	+ .07	+ .06	+ .05	+ .01	+ 130	201975	202105
VIII	- .06	+ .06	- .04	+ .10	+ 1300	192230	193530
IX	- .14	- .49	- .09	- .40	- 5200	193280	188080
XI	- .26	- .12	- .17	+ .05	+ 650	187430	188080
VII	- .37	- .14	- .25	+ .11	+ 1430	184480	185910
V	- .40	- .44	- .27	- .17	- 2210	191760	189550
VI	- .53	- .64	- .35	- .29	- 3770	187640	183870

Williams Ex 34 Table XXII

Chicago Sanitary District

St. Clair River Observations
Weighted Increment of Discharge for Normal Stage of Lake St. Clair assuming Normal Change of Lake St. Clair to be 66⅔% of Huron Change, and Lake St. Clair Increment to be -13000 c.f.s

1899 - 1902
Normal St. Clair 66⅔% Huron
Δ St. Clair 13000

1	2	3	4	5	6	7	8	9
Year & Month	St. Clair Mean Daily	Corrected Discharge	Multiplier	Weighted Discharge Col. 3 · Col. 4	Huron Mean Daily	Weighted Elevation Col. 6 · Col. 4	Weighted Centers of Gravity Col. 3	Weighted Centers of Gravity of Col. 6
II	575.618	208800	8	1670400	581.115	4648.920		
III	.620	205480	6	1232880	.072	3486.432		
IV	420	202510	4	810040	580.842	2323.368	204244	580.912
X	020	202300	8	1618400	.794	4646.352		
I	420	202105	10	2021050	77.7	5807.770		
XII	420	193530	7	1354710	.639	4064.473	195080	580622
IX	574.870	188080	9	1692720	.535	5224.995		
II	575.239	188080	8	1504640	439	4643.512		
VIII	.220	185910	6	1115460	.333	3481.998	188208	580404
V	574.920	189550	10	1895500	.304	5803.040		
VI	.720	183870	8	1470960	.171	4641.368		
			84					

$$\text{Increment} = \frac{204244}{188208} \Big/ \frac{16036}{508} \div \frac{580912}{580404} = 31370 \text{ c.f.s.}$$

Williams Ex. 34. Table XXXII

Chicago Sanitary District

St. Clair River Observations

Normal Change of Lake St. Clair from Mean of 1890 to 1910 for Gaging Periods of 1899 to 1902, assuming St. Clair Change to be 89% of Huron Change, and observed Variation from such Normal Change, and discharges corrected to Normal Stage for Increment of Lake St. Clair = -13000 c.f.s

1	2	3	4	5	6	7	8
Group	Change from Mean.				Discharge		
	Huron	St. Clair Observ'd	St. Clair Normal	Diff.	Correction due St. Clair.	Observed	Corrected
II	+ .42	+ .26	+ .37	- .10	- 1430	209060	207630
III	+ .31	+ .26	+ .33	- .07	- 910	205330	204440
IV	+ .14	+ .06	+ .12	- .06	- 780	202900	202120
V	+ .09	- .34	+ .08	- .42	- 5460	207300	202040
J	+ .07	+ .00	+ .06	- .00		201975	201975
VII	- .06	+ .06	- .05	+ .11	+ 1430	192230	193660
IX	- .14	- .49	- .12	- .37	- 4810	193280	188470
XI	- .26	- .12	- .23	+ .11	+ 1430	187430	188860
XII	- .37	- .14	- .33	+ .19	+ 2470	184480	186950
X	- .40	- .44	- .36	- .08	- 1040	191760	190720
VI	- .53	- .64	- .47	- .17	- 2210	187640	185430

Williams Ex. 34.

Table XXXIII

Chicago Sanitary District

St. Clair River Observations.
Weighted Increment of Discharge for Normal Stage of Lake St. Clair assuming Normal Change of Lake St. Clair to be 89 % of Huron Change, and Lake St. Clair Increment to be -13000 cfs

1899-1902
Normal St. Clair 89% Huron
& St. Clair = 13000

1	2	3	4	5	6	7	8	9
Stage	St. Clair Mean Daily	Corrected Discharge	Multiplier	Weighted Discharge Col. 3 × Col. 4	Huron Mean Daily	Weighted Elevation Col. 6 × Col. 4	Weighted Centers of Gravity of Col. 3	Weighted Centers of Gravity of Col. 6
II	575.516	207630	8	1661040	581.115	4648920		
III	.620	204440	6	1226640	.072	3480432		
IV	.420	202120	4	808480	580.842	2373368	203,673	580.912
X	.000	202040	8	1616320	.794	4646352		
I	.420	201975	10	2019750	.777	5807770		
IX	.120	193660	7	1355620	.639	4064473	195,325	580.622
IX	574.870	188470	9	1696230	.555	5224995		
II	575.239	188860	8	1510880	.439	4643512		
IX	.220	186950	6	1121700	.333	3481998	189,064	580.406
V	574.930	190720	10	1907200	.304	5803040		
VI	.720	185430	8	1483440	.171	4641368		
			84					

Increment. $\frac{203673}{189064} \quad 14,609 \div \frac{580912}{580404} \quad .508 = 28,758$ c.f.s..

Williams Ex. 34. Chicago Sanitary District Table XXXII
St. Clair River Sheet 1
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1908 - 1910

Group	Date	Lake Surfaces Huron Mean Daily	Lake Surfaces St Clair Mean Daily	Date	Observed Discharge	Weight by Time Interval	Weighted Discharge
					C.F.S.		C.F.S.
	1908-11-6		575.43				
	7	580.70	.37	1908-11-7	190420	0.50	95210
				7	187780	0.50	93890
XII				7	186930	0.50	93465
	8	.58	.36				
	9	.59	.37				
				9	191380	0.75	143535
				9	197460	0.75	148095
	10	51	32	10	191160	0.33	63720
				10	192570	0.33	64190
				10	190160	0.33	63387
	11	50		11	191870	0.50	95935
				11	195090	0.50	97545
		580.576	575.37		191480	5.0	191792
	1908-12-8		575.04				
	9	580.33	4.97	1908-12-9	186800	.5	93400
				9	183700	.5	91850
	10	.10	4.97	10	181600	.5	90800
XIII				10	179300	.5	89650
	11	.14	4.99	11	179600	1.0	179600
Observations	12	.35	5.00	12	179600	.75	134700
	13	.22	5.00	12	181200	.75	135900
	14	.17	5.00	14	168000	.75	126000
9.9 to				14	173300	.75	129975
22	15	.25	4.35	15	182500	1.0	182500
	16	.27	4.92	16	183900	.5	91950
0813				16	185900	.5	92950
to	17	.05	4.92	17	191000	1.0	191000
0815	18	.03		18	181500	1.0	181500
		580.191	574.976		181279	10.0	181178
	1909-11-4		575.09				
	5	580.17	.09	1909-11-5	184600	.25	46150
				5	183400	.25	45850
				5	182900	.25	45725
XIV				5	177800	.25	44450
	6	.07	.09	6	181000	.625	113125
	7	579.96	.08	6	180800	.625	113000
Observations	8	580.29	.05	6	183700	.625	114812
	9	.02	.09	6	180600	.625	112875
	10	579.94	.08	10	169000	1.75	295750
9.37 to	11	.98	.08	10	174500	1.75	305375
98	12	580.26	.04	13	175200	2.5	438000
	13	579.99	.06	15	183700	.75	137775
0.91 to	14	.91	.06	15	199100	.75	149325
0.98	15	580.33	.05	16	187600	1.0	187600
	16	.00	.16	16	171000	1.0	171000
	17	.05	.09	19	176600	1.0	176600
	18	.35	.02	19	183800	1.0	183800
	19	.06	.08	20	163300	.5	81650
	20	.02		20	178500	.5	89250
		580.085	575.076		180374	18.00	179040

Williams Ex 34. Table XXXIV
Sheet 2

Chicago Sanitary District
St. Clair River
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1908 - 1910

Group	Date	Lake Surfaces Huron Mean Daily	Lake Surfaces St. Clair Mean Daily	Date	Observed Discharge	Weight by Time Interval	Weighted Discharge
	1909-11-25		575.23		C.F.S.		C.F.S.
	26	580.05	.21	1909-11-26	179800	.5	89900
	27	579.90	.15	26	181200	.5	90600
	28	580.26	.10	27	169400	.67	112934
XV				27	168500	.67	112334
	29	.15	.12	27	169700	.66	113134
Observations				30	176100	.83	146750
	30	.08	.12	30	178700	.83	148917
949				30	178700	.83	148917
to	12-1	.03	.11	12-2	178200	.375	66825
957	2	579.90	.10	2	174200	.375	65325
				2	175000	.375	65625
	3	.98	.08	2	176000	.375	66000
0903	4	580.01	.06	3	178600	1.0	178600
to				4	175300	.75	131475
0923	5	579.78	.16	4	172300	.75	129225
	6	.99		6	161100	.75	120825
				6	179000	.75	134250
		580.012	575.131		174812	11.00	174694
	1910-5-16		575.54				
	17	580.13	.59	1910-5-17	165560	1.0	165560
				18	188020	.33	62673
XVI	8	.45	.58	18	186640	.33	62213
				18	190920	.33	63640
Observations				19	179040	.2	35808
	19	.35	.55	19	186240	.2	37248
963				19	182660	.2	36532
to				19	177190	.2	35438
979				19	174720	.2	34944
	20	.24	.55	20	179640	.2	35928
				20	179850	.2	35970
				20	180940	.2	36188
				20	178300	.2	35660
				20	187220	.2	37444
	21	.36		21	188150	.5	94075
				21	187630	.5	93815
		580.306	575.562		182045	5.00	180627

Williams Ex. 34. Table XXXIV Sheet 3

Chicago Sanitary District.
St. Clair River.
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1908 - 1910.

Group	Date	Lake Surfaces Huron Mean Daily	Lake Surfaces St. Clair Mean Daily	Date	Observed Discharge	Weight by Time Interval	Weighted Discharge
					C.F.S.		C.F.S.
	1910-6-12		575.70				
	13	580.55	.70	1910-6-13	189370	.2	37874
				13	190510	.2	38102
				13	188380	.2	37676
				13	187800	.2	37560
				13	187720	.2	37544
	14	.56	.69	14	189910	.33	63303
				14	187480	.33	62493
				14	189330	.33	63299
				14	189290	.33	63097
				14	184720	.33	61573
	15	.57	.68	14	186560	.33	62187
				15	185860	1.0	185860
				17	186280	1.0	186280
	16	.53	.67	18	191410	3	57423
				18	187030	3	56109
				18	190390	3	57117
				18	185620	3	55686
	17	.48	.66	18	189080	3	56724
				17	185860	1.0	185860
				17	186280	1.0	186280
	18	.55	.68	18	191410	3	57423
				18	187030	3	56109
				18	190390	3	57117
				18	185620	3	55686
	19	.51	.65	18	189080	3	56724
				20	179640	.4	71936
				20	184600	.4	73840
				20	186740	.4	74696
				20	190620	.4	76248
				20	188320	.4	75328
				22	182870	.5	91435
				22	183230	.5	91615
				22	182380	.5	91190
	20	.54	.68	23	189260	.333	63087
				23	190240	.333	63413
				23	189200	.333	63067
				24	199060	.333	66353
				24	193580	.333	64527
				24	192480	.333	64160
	21	.54	.66	25	186620	.75	139965
				25	193080	.75	144810
				27	185900	.5	92950
				27	184460	.5	92230
				27	184860	.5	92430
	22	.51	.65	28	192300	1.0	192300
				29	193400	.333	64533
				29	192530	.333	64177
				29	186710	.333	62237
	23	.55	.65	30	186940	.2	37388
				30	185200	.2	37040
				30	182340	.2	36468
				30	185770	.2	37154
				30	184400	.2	36880
	24	.52	.66	1910-7-1	184330	.2	36866
				1	183560	.2	36712
				1	188760	.2	37752
				1	186360	.2	37272
				1	185090	.2	37018
	25	.48	.67	2	184780	.25	46195
	26	.48	.67	2	183460	.25	45865
	27	.52	.66	2	183010	.25	45753
				2	188780	.25	47195
		580.58	575.64		187792	20.000	187999

Williams Ex 34

Table XXXIV
Sheet 4

Chicago Sanitary District
St. Clair River
Discharge at Constant Stages
Gagings Weighted by Days in Periods
1908 - 1910

Group	Date	Lake Surfaces Huron Mean Daily	Lake Surfaces St. Clair Mean Daily	Date	Observed Discharge	Weight by Time Interval	Weighted Discharge
	1910-8-7		575.63		C.F.S.		C.F.S.
	8	580.30	.54	1910-8-8	186260	.25	46565
				8	185060	.25	46265
				8	183740	.25	45935
				8	181570	.25	45392
	9	25	56	9	176100	.2	35220
XVIII				9	173300	.2	34660
				9	168130	.2	33626
Observations				9	171370	.2	34274
				9	175440	.2	35088
	10	39	5	10	187310	.167	31218
9423				10	184530	.167	30755
To				10	186390	.166	31065
152				10	185390	.167	30898
				10	186260	.167	31043
				10	185710	.166	30951
	11	36	.51	11	183980	.2	36796
				11	184870	.2	36974
				11	186820	.2	37364
				11	183020	.2	36604
				11	184510	.2	36902
	12	29	.51	12	179010	.2	35802
				12	176260	.2	35252
				12	177650	.2	35530
				12	181000	.2	36200
	13	21		13	180340	.2	36068
				13	181920	.2	36384
				13	178380	.2	35676
				13	183940	.2	36788
				13	179420	.2	35884
				13	181420	.2	36284
		580.29	575.535		181130	6.00	181071

Williams Ex. 34. Table XXXI

Chicago Sanitary District

St. Clair River Observations
Elevations of Lake Surfaces and Variations from Means, during selected Gaging Periods of 1908 to 1910 inclusive.

Mean Elevations for Open Season

Lake Huron.	1890 to 1910	580.70
Lake St. Clair	1890 to 1910	575.36

Gaging	Group	Days	Period	Lake Huron		Lake St. Clair.	
				Elevation	Change from Mean	Elevation	Change from Mean
10	XII	5	1908-11-7/11	580.576	- .12	575.370	+ .01
55	XVII	20	1910-6-9/2	.520	- .18	.664	+ .30
16	XVI	5	1910-5-17/21	.306	- .39	.562	+ .20
30	XVIII	6	1910-8-8/13	-.290	- .41	.533	+ .17
14	XIII	10	1908-12-9/18	.191	- .51	574.976	- .38
19	XIV	16	1909-11-1/26	.085	- .62	575.076	- .28
17	XV	11	1909-11-26/C	.012	- .69	.131	- .23

Williams Ex. 34. Table XXXVI

Chicago Sanitary District

St. Clair River Observations

Normal Change at Lake St. Clair from Mean of 1890 to 1910 for Gaging Periods from 1908 to 1910, assuming St. Clair Change to be 66⅔% of Huron Change, and observed variation from such Normal Change, and discharges corrected to Normal Stage for Increment of Lake St. Clair = 12000 c.f.s

1	2	3	4	5	6	7	8
Gage	Change from Mean					Discharge	
	Huron Observed	St. Clair Observed	St. Clair Normal	Diff	Correction due St. Clair	Observed	Corrected to Normal Stage
XII	- .12	+ .01	- .08	+ .09	+ 1080	191 792	192872
XIII	- .18	+ .30	- .12	+ .42	+ 5040	187999	193039
XVI	- .39	+ .20	- .26	+ .46	+ 5520	180627	186147
XVIII	- .41	+ .17	- .27	+ .44	+ 5280	181071	186351
XIII	- .51	- .38	- .34	- .04	- 480	181178	180698
XIV	- .62	- .28	- .41	+ .13	+ 1560	179040	180600
XV	- .69	- .23	- .46	+ .23	+ 2760	174694	177454

Williams Ex. 34 *Table XXXVII*

Chicago Sanitary District

St. Clair River Observations
Weighted Increment of Discharge for Normal Stage of Lake St. Clair assuming Normal Change of Lake St. Clair to be 66⅔% of Huron Change and Lake St. Clair Increment to be -12000 c.f.s.

1908 to 1910
Normal St. Clair - 66⅔% Huron
Δ St. Clair 12000

1	2	3	4	5	6	7	8	9
Group	St. Clair Mean Daily	Corrected Discharge	Multiplier	Weighted Discharge Col. 3 · Col. 4	Huron Mean Daily	Weighted Elevation Col. 6 · Col. 4	Weighted Centers of Gravity of Col. 5	Weighted Centers of Gravity of Col. 5
XII	575.370	192872	5	964300	580.570	2902.880		
XIII	.664	193039	20	3800780	.520	11610.400	190944	580.460
XVI	.562	186147	5	930735	.306	2901.530		
XVIII	.533	186351	6	1118106	.290	3481.740	185240	580.273
XIII	574.976	180698	10	1806980	.191	5801.910		
XIV	573.076	180600	10	2889600	.083	9281.360	179691	580.092
XV	.131	177454	11	1951994	.012	6380.132		
			73					

$$\text{Increment} = \frac{190944 - 179691}{11253} \div \frac{580.460 - 580.092}{.368} = 30,579$$

Williams Ex. 34. Table XXXVIII

Chicago Sanitary District

St. Clair River Observations

Normal Change at Lake St. Clair from Mean of 1890 to 1910 for Gaging Periods from 1908 to 1910, assuming St. Clair Change to be 89% of Huron Change, and observed variation from such Normal Change, and discharges corrected to Normal Stage for Increment of Lake St. Clair = 12000 c.f.s.

1	2	3	4	5	6	7	8
Group.	Change from Mean				Discharge		
	Huron Observ.	St. Clair Observ.	St. Clair Normal	Diff.	Correction due St. Clair.	Observed	Corrected to Normal Stage
XII	-.12	+.01	-.11	+.12	+1440	191792	193232
XVII	-.18	+.30	-.16	+.46	+5520	187999	193519
XVI	-.39	+.20	-.35	+.55	+6600	180627	187227
XVIII	-.41	+.17	-.36	+.53	+6360	181071	187431
XIII	-.51	-.38	-.45	+.07	+840	181178	182018
XIV	-.62	-.28	-.55	+.27	+3240	179040	182280
XV	-.69	-.23	-.61	+.38	+4560	174694	179254

Williams Ex. 34

Chicago Sanitary District

Table XXXIII

St. Clair River Observations
Weighted Increment of Discharge for Normal Stage of Lake St. Clair assuming Normal Change of Lake St. Clair to be 89% of Huron Change and Lake St. Clair Increment to be -12000 c.f.s

1908 to 1910
Normal St. Clair 89% Huron
Δ St. Clair 12000

1	2	3	4	5	6	7	8	9
Group	St. Clair Mean Daily	Corrected Discharge	Multiplier	Weighted Discharge Col. 3 · Col. 4	Huron Mean Daily	Weighted Elevation Col. 6 · Col. 4	Weighted Centers of Gravity of Col. 3	Weighted Centers of Gravity of Col. 6
XII	575.370	193232	5	966160	580.576	2902.880		
XVII	.664	193519	20	3870380	.520	11610.400	191,591	580.460
XVI	.562	187227	5	936135	.306	2901.530		
XVIII	.533	187431	6	1124586	.290	3481.740	180,380	580.273
XIII	574.976	182018	10	1820180	.191	5801.910		
XIV	575.076	182280	16	2916480	.085	9281.360	181,310	580.092
XV	.131	179254	11	1971794	.012	6380.132		
			73					

$$\text{Increment} = \frac{\frac{191591}{181310}}{16281} \div \frac{\frac{580.460}{580.092}}{.368} = 27{,}938$$

Williams Ex. 34

Table XL
Sheet 1

Chicago Sanitary District

Q for St Clair River
By Defendant's Equation

Q = (Huron Elev. - 582.70) 40,442 - (St Clair Elev. - 575.36) 13000 + 197,610

Date		Huron	Huron	Huron	St. Clair	St. Clair	St. Clair	Net	Discharge
Year	Month	Elevation	Rise	Increase	Elevation	Rise	Decrease	Increase	
1900	Jan.	579.82	0.08	35589	574.24	1.12	14560	21029	176581
	Feb.	579.93	0.04	13691	574.28	0.04	3900	9791	175322
	Mar.	579.80	0.02	5410	574.24	0.04	1300	4110	175012
	Apr.	579.78	0.02	1080	574.22	0.02	1300	780	174232
	May	579.80	0.02	1080	574.24	0.02	1300	780	173452
	June	579.83	0.03	1620	574.26	0.02	1300	320	173132
	July	579.86	0.03	1620	574.28	0.02	1300	320	172812
	Aug.	579.90	0.04	2160	574.30	0.02	1300	860	171952
	Sept.	579.94	0.04	2160	574.32	0.02	1300	860	171092
	Oct.	579.98	0.04	2160	574.34	0.02	1300	860	170232
	Nov.	580.00	0.02	1080	574.36	0.02	1300	220	170012
	Dec.	580.02	0.02	1080	574.38	0.02	1300	220	169792
	Av. Q = 184,949								
1901	Jan.	580.22	0.20	19412	574.63	0.25	23000	10182	179974
	Feb.	580.03	0.19	18446	574.74	0.11	12650	18796	178178
	Mar.	579.91	0.12	11646	574.74	0.00	0	11646	176532
	Apr.	579.85	0.06	5823	574.70	0.04	4600	2223	176309
	May	579.85	0.00	0	574.70	0.00	0	0	176309
	June	579.85	0.00	0	574.70	0.00	0	0	176309
	July	579.85	0.00	0	574.70	0.00	0	0	176309
	Aug.	579.85	0.00	0	574.70	0.00	0	0	176309
	Sept.	579.85	0.00	0	574.70	0.00	0	0	176309
	Oct.	579.85	0.00	0	574.70	0.00	0	0	176309
	Nov.	579.85	0.00	0	574.70	0.00	0	0	176309
	Dec.	579.93	0.08	7764	574.74	0.04	4600	7524	175833
	Av. Q = 202,292								
1902	Jan.	580.00	0.07	6794	574.76	0.02	2600	9394	175833
	Feb.	579.93	0.07	6794	574.74	0.02	2600	7594	175033
	Mar.	579.91	0.02	1942	574.74	0.00	0	1942	174940
	Apr.	579.89	0.02	1942	574.74	0.00	0	1942	174940
	May	579.87	0.02	1942	574.74	0.00	0	1942	174940
	June	579.85	0.02	1942	574.74	0.00	0	1942	174940
	July	579.85	0.00	0	574.74	0.00	0	0	174940
	Aug.	579.85	0.00	0	574.74	0.00	0	0	174940
	Sept.	579.85	0.00	0	574.74	0.00	0	0	174940
	Oct.	579.85	0.00	0	574.74	0.00	0	0	174940
	Nov.	579.85	0.00	0	574.74	0.00	0	0	174940
	Dec.	579.85	0.00	0	574.74	0.00	0	0	174940
	Av. Q = 184,992								

Williams Ex 34

Table XL
Sheet 1

Chicago Sanitory District

Q for St Clair River
By Defendant's Equation

$Q = (Huron\ Elev. - 580.70)40,442 - (St.\ Clair\ Elev. - 575.36)/3000 + 197,610$

Date		Huron		Huron		St. Clair		St. Clair		Net	
Year	Month	Elevation		Rise		Elevation		Rise		Increase	Discharge
1926											
	Jan.										
	Feb.										
	Mar.										
	Apr.										
	May										
	June										
	July										
	Aug.										
	Sept.										
	Oct.										
	Nov.										
	Dec.										
											$Av.\ Q = 183,738$
1927											
	Jan.										
	Feb.										
	Mar.										
	Apr.										
	May										
	June										
	July										
	Aug.										
	Sept.										
	Oct.										
	Nov.										
	Dec.										
											$Av.\ Q = 200,106$
1928											
	Jan.										
	Feb.										
	Mar.										
	Apr.										
	May										
	June										
	July										
	Aug.										
	Sept.										
	Oct.										
	Nov.										
	Dec.										
											$Av.\ Q = 208,021$

Williams Ex. 34.

Table XL
Sheet 3

Chicago Sanitary District

Q for St. Clair River
By Defendant's Equation

Q = (Huron Elev. - 580.70) 40,442 - (St. Clair Elev. - 573.36) 13,000 + 197,610

Date		Huron		Huron	St. Clair	St. Clair	St. Clair	Net	
Year	Month	Elevation		Rise	Increase	Elevation	Rise	Decrease	Increase	Discharge
1906	Jan	580.33		0.17	6873	573.40	0.04	520	7392	190315
	Feb	580.50		0.01	24266	573.36	1.00	13000	13266	203581
	Mar	580.51		0.00	9702	573.36	1.00	1300	8402	211983
	Apr	580.51		0.00	20433	573.45	0.09	11700	8733	220716
	May	580.51		0.00	6609	573.45	0.00	0	6609	227325
	June	580.57		0.06	2178	573.45	0.00	0	2178	229503
	July	580.61		0.04	1742	573.45	0.00	0	1742	231245
	Aug	580.63		0.02	871	573.45	0.00	0	871	232116
	Sept	580.63		0.00	0	573.45	0.00	0	0	232116
	Oct	580.63		0.00	0	573.45	0.00	0	0	232116
	Nov	580.63		0.00	0	573.45	0.00	0	0	232116
	Dec	580.63		0.00	0	573.45	0.00	0	0	232116
Av. Q - 209248										
1907	Jan	580.63		0.00	2022	573.40	0.02	260	2287	234403
	Feb	580.63		0.00	8000	573.48	0.08	10400	2431	236834
	Mar	580.63		0.00	0	573.47	0.01	1300	1300	238134
	Apr	580.63		0.00	3900	573.60	0.13	16900	20800	217334
	May	580.63		0.00	0	573.60	0.00	0	0	217334
	June	580.63		0.00	0	573.60	0.00	0	0	217334
	July	580.63		0.00	0	573.60	0.00	0	0	217334
	Aug	580.63		0.00	0	573.60	0.00	0	0	217334
	Sept	580.63		0.00	0	573.60	0.00	0	0	217334
	Oct	580.63		0.00	0	573.60	0.00	0	0	217334
	Nov	580.63		0.00	0	573.60	0.00	0	0	217334
	Dec	580.62		0.00	0	573.40	0.04	520	520	217854
Av. Q - 208676										

Mean Q 1900 to 1907 = 198002 cfs.

Williams Ex. 34.

Table XLI
Sheet

Chicago Sanitary District
Discharge Data
of
St. Lawrence River

1	2	3	4	5	6	7	8	9
Group No	No Observ.	Date	Observed Elevation	Observed Discharge	Optimizing Mean Daily	Multiplier	Weighted Discharge	Corrected Mean Daily
		1930-9-25			244.06			244.97
	1	26	244.14	222800	4.13	1.5	334200	4.96
	2	27	4.08	223000	4.13	.5	111500	5.01
	3	27	4.10	223300		.5	111650	
	4	28	3.99	219700	4.04	1.0	219700	4.96
I	5	29	4.02	221100		1.0	221100	
		29			4.02			4.91
		30			4.01			4.86
	6	10-1	3.94	218300	3.98	2.5	545750	4.90
		2			3.97			4.84
	7	3	4.04	219400	4.07	1.5	329100	4.83
	8	4	4.12	223800	4.06	1.0	223800	4.83
	9	5		223000		.5	111500	
			1952.43	1994,400	244.047	10.0	2308300	2449.14
			244.05	221,600	244.047		230830	244.914
		1930-10-8			244.02			244.95
	10	9	243.90	217700	3.87	1.0	217,700	4.84
	11	10	3.80	216200	3.87	1.0	216200	4.81
II	12	11	3.94	219400	4.04	1.0	219400	4.88
	13	12		221100		1.0	221100	
			731.64	874,400	975.80	4.0	874,400	979.62
			243.88	218,600	243.950		218,600	244.905
		1930-10-18			243.83			244.29
	14	17	243.84	217600	3.99	1.0	217600	4.76
	15	18	4.05	223800	4.02	1.0	223800	4.81
	16	19	3.88	209400	3.82	2.0	418800	4.49
		20			3.84			4.60
		21			3.94			4.69
III	17	22	3.81	215000	3.77	2.0	430000	4.57
	18	23	3.71	213300	3.79	1.0	213300	4.88
	19	24	3.89	217700	3.84	1.0	217700	4.61
	20	25	3.82	208300	3.59	1.0	208300	4.34
	21	26	3.70	212700		1.0	212700	
			1980.40	1,717,800	2438.22	10.0	2142,200	2446.67
			243.80	214,725	243.822		214220	244.467
		1930-10-29			243.78			244.29
	22	29	243.78	210800	3.72	1.0	210800	4.23
	23	30	3.86	189300	3.67	1.0	189300	4.26
	24	31	3.69	209900	3.70	1.0	209900	4.23
III	25	11-1	3.90	213800	3.98	1.0	213800	4.40
	26	2	4.07	225700	4.12	1.0	225700	4.60
	27	3		211700		1.0	211700	
			1818.20	1264900	1462.27	6.0	1260900	1466.98
			243.88	210,150	243.712		210,150	244.497

Williams Ex 34.

Table XLI
Sheet 2

Chicago Sanitary District
Discharge Data
of
St. Lawrence River

1	2	3	4	5	6	7	8	9
Group No.	No. Obsn.	Date	Observed Elevation	Observed Discharge	Conservancy Mean Daily	Multiplier	Weighted Discharge	Corrego Mean Daily
I	46	1901-5-5			244.91			246.06
	47	6	244.83	243400	4.86	.333	81133	6.02
	48	6	4.88	249100		"	83067	
	49	6	4.93	249000		"	83000	
	50	7	4.94	248900	4.93	"	82967	6.00
	51	7	4.97	252100		"	84033	
	52	7	5.04	251700		"	83900	
	53	8	4.80	244500	4.86	"	81500	5.96
	54	8	4.89	243900		"	81300	
	55	9	4.92	246100		"	82033	
	56	9	4.80	248200	4.82	"	82733	5.95
	57	9	4.78	248500		"	82833	
	58	9	4.85	246700		"	82233	
	59	10	4.66	242400		"	80800	
	60	10	4.77	245600		"	81867	
	61	10	4.84	246700		"	82233	
			3672.90	3,706,900	122.438	5.00	1,234,632 ✓	1279.99
			244.86	247,127	244.878		247,126	245.998
II	70	1901-6-17			244.83			245.93
	71	18	244.88	250000	4.88	.333	83333	5.93
	72	18	4.92	249700		"	82900	
	73	18	4.93	248800		"	82933	
	74	19	4.84	248600	4.92	"	82933	5.95
	75	19	4.95	250600		"	83533	
	76	19	5.09	249700		"	83233	
	77	20	4.84	246000	4.89	"	82000	5.96
	78	20	4.87	248900		"	82967	
	79	20	5.09	246100		"	82033	
	80	21	4.91	250500	4.98	"	83500	5.98
	81	21	5.01	249800		"	83267	
	82	21	5.08	252600		.333	84200	
	83	22	4.82	246800	4.91	.75	185100	5.94
		22	4.90	251100		.25	188325	
		23			5.05			6.03
	84	24	5.05	281400	5.07	.5	125700	6.04
	85	24	5.05	251500		.5	125750	
	86	24	5.12	252700		.5	126350	
	87	25	4.99	252800	5.01	.333	84200	6.01
	88	25	5.00	253100		"	84367	
	89	25	5.02	252600		"	84200	
	90	25	4.94	250700		"	83567	
	91	26	5.02	250200		"	83400	
	92	26	4.97	249300		.333	83100	
			563457	5,762,300	220.431	9.00	2258,859 ✓	2213.83
			244.98 ✓	250,109	244.948		250,649 ~	245.981

Williams Ex. 34

Table XLII

Chicago Sanitary District
INCREMENT OF DISCHARGE
OF
St. Lawrence River
(Three Points Section)

Computed for 1 foot rise at Ogdensburg

1	2	3	4	5	6	7	8	9	10	11
Sequence	Group	Days	Preceding Mean Daily	Multiplier	Weighted Elevations	Centers of Gravity Elevation	Discharge	Multiplier	Weighted Discharge	Centers of Gravity Discharge
23	VI	9	244.946	9	2204.51	244.921	250099	9	2,250,891	249,837
15	V	5	876	5	1224.38	244.219	247126	5	1,235,630	226,644
9	I	10	047	10	2440.47		220830	10	2,208,300	
4	II	4	3.950	4	975.80	243892	218600	4	874,400	216,193
8	III	10	3.832	10	2438.22		214220	10	2,142,200	
6	IV	6	3.712	6	1462.27		210130	6	1260,900	
63		44		44	10745.65			44	9,972,325	
					244.219				226,644	

244.921 − 243.892 = 1.029

249.837 − 218,193 = 31,644

31,918 = Increment

Equation:

$X = 31,918\,Y - 7,568,368$

Williams Ex. 34. Chicago Sanitary District
Q for St. Lawrence River
(H-243, Q-192,400, A 28870)
By Complainant's Equation

Table XLIII

Date		Lake Height	Discharge	Date		Lake Height	Discharge	Date		Lake Height	Discharge
Year	Month	Quarterday	C.F.S.	Year	Month	Quarterday	C.F.S.	Year	Month	Quarterday	C.F.S.
1900	Jan	243.97	220400	1903	Jan	243.61	215785	1906	Jan	245.30	258800
	Feb		211200		Feb		212715		Feb		253300
	Mar		204000		Mar		210880		Mar		252000
	April		196800		April		207200		April		251300
	May		189600		May		203320		May		250600
	June		182400		June		199440		June		249900
	July		175200		July		195560		July		249200
	August		168000		August		191680		August		248500
	Sept		160800		Sept		187800		Sept		247800
	Oct		153600		Oct		183920		Oct		247100
	Nov		146400		Nov		180040		Nov		246400
	Dec		139200		Dec		176160		Dec		245700
1901	Jan	244.24	228200	1904	Jan	244.37	232000	1907	Jan	245.09	252785
	Feb		221200		Feb		228920		Feb		252320
	Mar		214200		Mar		225840		Mar		251855
	April		207200		April		222760		April		251390
	May		200200		May		219680		May		250925
	June		193200		June		216600		June		250460
	July		186200		July		213520		July		249995
	August		179200		August		210440		August		249530
	Sept		172200		Sept		207360		Sept		249065
	Oct		165200		Oct		204280		Oct		248600
	Nov		158200		Nov		201200		Nov		248135
	Dec		151200		Dec		198120		Dec		247670
1902	Jan	244.42	233400	1905	Jan	244.11	224399	1908	Jan	245.61	267850
	Feb		226400		Feb		221320		Feb		
	Mar		219400		Mar		218240		Mar		
	April		212400		April		215160		April		
	May		205400		May		212080		May		
	June		198400		June		209000		June		
	July		191400		July		205920		July		
	August		184400		August		202840		August		
	Sept		177400		Sept		199760		Sept		
	Oct		170400		Oct		196680		Oct		
	Nov		163400		Nov		193600		Nov		
	Dec		156400		Dec		190520		Dec		

Mean Q 1900 to 1902 = 240,818 c/s.

Mean Q 1900 to 1908 = 247,762 c/s.

Williams Ex. 34. Table XLIIe

Chicago Sanitary District
Q for St. Lawrence River
(H = 244.22, Q = 226644, Δ = 31920
By Defendant's Equation

Date	Gage Height	Discharge
Year	Hour	Quarterday	C.F.S.
1900			
1901			
1902			

Mean Q 1900 to 1907 = 241908

Mean Q 1900, 1901, 1902 = 242277

Table XLIV.

Chicago Sanitary District.

Relative Fluctuations of Lakes.

Ontario-Erie.

Erie Elevation Decreasing.

1	2	3	4	5	6
Period	Year	Erie		Ontario	
		Elevation	C of G	Elevation	C of G
1860–1903	1876	573.70		247.10	
	62	369		263	
	61	358		760	
	60	350		696	
	59	348		657	
	58	340		719	
	57	334		730	
	56	334		760	
	55	351		706	
	54	329		650	
	53	328		759	
	52	327		668	
	51	324	573.180	685	246.982
	50	305		707	
	49	296		658	
	48	290		694	
	47	289		618	
	46	265		653	
	45	281		694	
	44	244	572.620	689	246.172
	43	268		693	
	42	277		733	
	41	261		682	
	40	261		651	
	39	268		619	
	38	253		621	
	37	244		594	
	36	253		647	
	35	236		608	
	34	228		577	
	33	220	572.153	553	245.497
	32	215		612	
	31	214		638	
	30	214		587	
	29	210		573	
	28	209		598	
	27	196		620	
	26	194		526	
	25	193		620	
	24	184		627	
	23	173		602	
	22	139		506	
	21	139		562	
	20	117		529	

572.180 246.982 4445 = 1444.5 Outlook
572.153 245.497 1.029 2.16
.027 1.485

Williams Ex. 34 Table XII

Chicago Sanitary District
Niagara Discharge

1 ft. rise in Lake Erie
All groups considered
Buffalo Gage

1	2	3	4	5	6	7	8	9	10	11
Sequence	Group	Days	Buffalo Mean Daily	Multiplier	Weighted Elevations	Coef. of Elev.	Discharge	Multiplier	Weighted Discharge	Coef. of Discharge
6	XIII	3	57268	3	171786		217787	3	653301	
19	XIII	13	254	13	744302	572296	202942	13	2638246	199868
8	IV	4	209	4	2288.36		193238	4	772952	
6	I	5	202	5	2860.10		194355	5	971675	
8	XI	6	196	6	3431 76	63	193289	6	1139734	1220
22	VII	10	194	10	5719.40	571992	186405	10	1864050	199088
10	III	7	189	7	4003.29		184471	7	1291297	
6	II	6	184	6	3431.04	25	186567	6	1119402	4304
11	X	6	181	6	3429.66	571768	184333	6	1105998	184334
3	IX	3	155	3	1714.65		185787	3	557301	
12	XI	7	151	7	4000.57		184511	7	1291577	
[illegible]										
8	VIII	4	141	4	2286.64		182688	4	730752	
[illegible]										

572296
4725
569

199868
199986
14002

Increment = [illegible] per sec
14002 ÷ 8.569 = 2665.
Equation: X = 2665Y − 14,778,972
X = [illegible]

115		74	6862.58	78	42325.29		2294313	74	14130285	

Williams Ex. 34

Table XLVa
Sheet 1
(5 Sheets)

Chicago Sanitary District
Niagara River
Discharge at Constant Stages

Gagings Weighted by Days in Periods
1898-1900

1	2	3	4	5	6	7	8
Group	No. of Obsn.	Date	Observed		Buffalo Mean Daily	Multiplier	Weighted Discharge
			Elevation	Discharge			
	6	1898-9-12			571.75		
	7	13	572.08	195800	1.93	0.75	146850
	13	13	1.96	195000		0.75	146250
	14	14			2.05		
I	15	15	2.01	195500	2.13	1.00	195500
	8	15	2.16	198900		1.00	198900
	9	16			2.15		
	10	17	1.74	188500	2.05	0.75	141375
	11	17	1.75	190400		0.75	142800
6			3431.65	1164100	3432.10	5.00	971675
Mean			571.94	194017	572.02		194335
	20	1898-9-28			571.85		
	21	29	571.85	188900	1.85	0.75	141675
	30	29	1.73	187400		0.75	140550
	22	30			1.85		
II	23	10-1	1.42	181900	1.75	1.25	227375
		1	1.48	184800		1.25	231000
		3			1.85		
	24	4	1.65	188700	1.85	1.00	188700
	25	4	1.76	190100		1.00	190100
6			3429.89	1121800	400285	6.00	1119400
Mean			571.65	186967	571.84		186567
	32	1898-10-12			572.15		
	33	13	571.47	188500	1.75	0.75	141375
		13	1.84	190400		0.75	142800
	34	14			2.25		
	35	15	1.80	188900	2.23	1.00	188900
		15	2.03	193300		1.00	193300
III	36	16			1.75		
	37	17	1.14	183200	1.13	0.50	91600
	38	17	1.05	173600		0.50	87000
	39	17	0.75	173800		0.50	86900
		17	0.62	169200		0.50	84600
	40	18			1.65		
	41	19	1.41	180200	2.13	0.75	135150
		19	1.61	184900		0.75	138675
10			5713.65	1828200	4575.10	7.00	1291300
Mean			571.36	182820	571.89		184471

Williams Ex. 34

Table XLV
Sheet 2

Chicago Sanitary District
Niagara River
Discharge at Constant Stages

Gagings Weighted by Days in Periods
1898-1900

1	2	3	4	5	6	7	8
Group	No of Obsn.	Date	Observed Elevation	Observed Discharge	Buffalo Mean Daily	Multiplier	Weighted Discharge
IV	49	1898-10-31	572.29	207100	571.95		
	50	11-1	1.27	195800	2.13	0.50	103550
	51	2	1.26	194900		0.50	97900
	52	3	1.83	193000	2.55	0.75	146175
		4				0.75	144750
	53		1.60	188000	1.95		
	54		1.33	186900	1.83	0.375	70500
	55		1.47	187600		0.375	70088
	56		1.24	183700		0.375	70350
						0.375	69638
	8		457.99	1539000	2860.45	4.00	772951
Mean			571.75	192375	572.09		193238
V	98	1899-2-13	571.94	161300	571.55		
	99	14	1.99	160800	1.33	1.00	161500
	100	15	1.92	160700	1.23	0.25	42700
	101	16	1.91	159900		0.25	42175
	102	17	1.91	158700		0.25	41475
	103	18	1.91	158400		0.25	44275
	104	19	1.90	159400	1.45	0.50	84700
	105	20	1.90	160900		0.50	84050
	106	21	1.89	159700	1.45	0.50	84800
	107	22	1.90	157500		0.25	39187
	108	23	1.93	161000		0.25	40833
	10		19.10	1597000	5.03	4.00	690523
Mean			571.91	159700	571.51		172631
VI	1	1899-8-29	571.80	191900	571.95		
	2	30	2.14	200300	1.93	1.00	191900
	3	31	1.93	193800	2.03	0.25	46787
	4	9-1	1.85	192600		0.25	48267
	5	1	1.87	191100	1.95	0.25	48150
	6	2	2.25	201600		0.50	99050
	7	3	1.77	189900	1.95	0.50	101800
		4			2.13	1.50	284850
	8		1.89	190600	7.73	1.50	285900
	8		457.547	1582800	400375	6.00	1159734
Mean			571.93	195350	571.96		193289

Williams Ex 34

Table XLVa
Sheet 3

Chicago Sanitary District
Niagara River
Discharge at Constant Stages

Gagings Weighted by Days in Periods
1898-1900

1	2	3	4	5	6	7	8
Group	No. of Obsns.	Date	Observed Elevation	Observed Discharge	Buffalo Mean Daily	Multiplier	Weighted Discharge
	12	1899-9-13			572.05		
	13	14	571.73	188200	1.85	1.00	188200
	14	15	1.63	184600	1.75	0.33	61567
	15	16	1.75	188400		0.33	62800
	16	17	1.75	188200		0.33	61733
	17	18	1.79	189800	1.85	0.50	92900
	18	19	1.63	182300		0.50	91250
		16	1.49	180600		0.50	90300
		17			1.85		
	19	18	1.75	185000	1.85	0.50	92500
	20	19	1.67	180300		0.50	90150
	21	20	1.92	191600		0.50	95800
III	22	19	1.80	183300	1.55	0.33	61100
	23	19	1.33	176000		0.33	58667
	24	19	1.29	175100		0.33	57867
	25	20	1.78	186000	1.85	0.33	62000
	26	20	1.77	188800		0.33	62933
	27	20	1.63	186400		0.33	62133
	28	21	1.92	187200	2.25	0.50	93600
	29	21	2.32	201000		0.50	100500
	30	22	1.55	181800	2.05	0.50	90900
	31	23	2.06	193600		0.50	96800
	32	23	1.50	183300	2.45	0.50	91650
	33	23	1.33	181800		0.50	90800
	22		12577.95	4092500	629.35	10.00	1864050
Mean			571.72	186023	571.94		186405
	34	1899-10-3			571.45		
	35	4	571.66	186300	1.55	1.00	186300
	36	5	1.39	181200	1.40	1.00	181200
III	37	6	1.42	181600	1.45	0.50	90800
	38	6	1.42	181400		0.50	90700
	39	7	1.37	178400	1.15	0.50	89200
	39	7	1.28	176700		0.50	88350
	6		3428.76	1093300	2857.05	4.00	730750
Mean			571.46	182217	571.41		182688

Williams Ex. 34. Table XLVa Sheet 4

Chicago Sanitary District
Niagara River
Discharge at Constant Stages

Gagings Weighted by Days in Periods
1898-1900

1	2	3	4	5	6	7	8
Group	No. of Obsn.	Date	Observed Elevation	Observed Discharge	Buffalo Mean Daily	Multiplier	Weighted Discharge
IX	41	1899-10-10			571.55		
	42	11	571.35	181800	1.35	0.50	90900
	43	11	1.60	186600		0.50	93300
	44	12	1.39	189000	1.55	0.50	94500
	45	12	1.33	180200		0.50	90100
		13	1.48	182300	1.55	1.00	182500
	5		2857.35	920100	2286.20	3.00	551300
Mean			571.47	184020	571.55		183767
X	55	1899-10-29			571.85		
	56	30	571.63	190400	1.35	0.50	95200
	57	30	1.57	185400		0.50	92700
	58	31	1.22	180600	1.15	0.50	90300
	59	31	1.13	170400		0.50	85200
	60	11- 1	1.61	183800	1.35	1.00	183800
	61	2	0.78	169400	0.85	0.50	84700
	62	3	0.82	168800		0.50	84400
	63	3	1.16	175800	1.95	0.50	87900
	64	3	0.67	165200		0.50	82600
	65	4	2.89	216400	2.55	0.50	108200
		4	3.29	222000		0.50	111000
	11		6286.67	2028200	4001.25	6.00	1106000
Mean			571.52	184382	571.61		184333
XI	70	1899-11-22			571.45		
	71	23	570.73	167500	0.85	0.50	83750
	72	23	0.54	164300		0.50	82150
	73	24	1.32	182700	1.45	0.50	91350
	74	24	1.45	185500		0.50	92750
	75	25	1.43	182200	1.45	0.75	136650
		25	1.30	181900		0.75	136425
	76	26			1.55		
	77	27	1.56	188400	1.55	0.75	141300
	78	27	1.72	191800		0.75	143850
	79	28	1.64	194500	1.95	0.50	97250
	80	28	1.88	193800		0.50	96850
	81	29	1.72	190200	1.85	0.50	95100
		29	1.68	188700		0.50	94350
	12		6857.33	2211000	4572.10	7.00	1291575
Mean			571.44	184250	571.51		184511

Williams Ex. 34. Table XLVO
Sheet 5

Chicago Sanitary District
Niagara River
Discharge at Constant Stages

Gagings Weighted by Days in Periods
1898-1900

1	2	3	4	5	6	7	8
Group	No. of Obser.	Date	Observed		Buffalo Mean Daily	Multiplier	Weighted Discharge
			Elevation	Discharge			
		1900-6-27			572.55		
	91	28	572.73	215900	2.65	0.50	107950
	92	29	3.04	218500		0.50	109250
XII	93	29	3.41	228800	2.65	0.50	114400
	94	29	2.94	214100		0.50	107050
	95	30	2.99	215200	2.65	0.50	107600
	96	30	2.95	214100		0.50	107050
	6		3437.96	1306600	229.050	3.00	653300
Mean			572.99	217767	572.62		217767
		1900-7-8			573.15		
	101	9	573.15	221400	2.75	0.50	110700
	102	9	2.69	205900		0.50	102950
	103	10	2.28	200700	2.45	0.50	100350
	104	10	2.71	214300		0.50	107150
	105	11	2.71	205000	2.65	0.50	102500
	106	11	2.26	193800		0.50	97900
	107	12	3.21	216900	2.75	0.50	108450
	108	12	3.04	213100		0.50	106550
XIII	109	13	2.30	199300	2.65	1.00	199300
	110	14	2.52	203200	2.35	0.75	152400
	111	14	2.26	194400		0.75	145800
		15			2.35		
	112	16	2.33	200700	2.45	0.75	150525
	113	16	2.15	196500		0.75	147375
	114	17	2.88	213200	2.35	0.50	107600
	115	17	2.36	201600		0.50	100800
	116	18	2.35	201300	2.35	1.00	201300
	117	19	2.11	201100	2.25	1.00	201100
	118	20	2.39	201600	2.35	1.00	201600
	119	21	2.25	193900	2.65	1.00	193900
	19		1087.09	3881900	801.5.50	13.00	2638250
Mean			572.53	204311	572.54		202942

Williams Ex 34 *Table XLII*

Chicago Sanitary District
Niagara Discharge

1 Ft rise in Lake Erie
All groups considered

$\frac{\text{Buffalo Mean Daily} + \text{Amherstburg Mean Daily}}{2}$ *gives governing elev*

1	2	3	4	5	6	7	8	9	10	11
Group	Group	Days	Buffalo Mean Daily	Multiplier	Weighted Elevations	Coef of Elev.	Discharge	Multiplier	Weighted Discharge	Coef of Discharge
6	XII	3	572.55	3	1717.65		217767	3	653300	
19	XIII	13	2.51	13	7442.63		202942	13	2638250	
6	I	5	2.25	5	2861.25	572.354	194335	5	971675	199868
8	II	6	2.24	6	3433.44		193289	6	1159734	
8	IV	4	200	4	2288.00		193238	4	772952	1290
10	III	6	2.08	6	3432.48	572.0[illegible]	184217	6	1105300	19[illegible]
22	VIII	10	203	10	5720.30		186405	10	1864050	
6	II	7	213	7	4004.91		187314	7	1311200	5120
11	X	6	1.77	6	3430.62	571.[illegible] 909	184333	6	1106000	18[illegible]
5	IX	5	1.74	5	1718.22		189767	5	551300	
6	VIII	4	1.72	4	2286.88		182600	4	730750	
12	XI	7	1.67	7	4001.69		184511	7	1291575	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]		[illegible]	[illegible]	—		[illegible]	[illegible]	
119		74		74	42335.07				[illegible]600.5	

2153210 *360175*

572.354
571.[illegible] 909
0.445

199868 5120

Increment = [illegible] = [illegible] *cu ft per sec.*
19763 + 0.445 = 33492

Equation:

$X = [illegible] - [illegible]$

$X = 33492\,Y - 19763.108$

Williams Ex. 34 Chicago Sanitary District Table XLVIII
Niagara Discharge
1 Ft. rise in Lake Erie
All groups considered

$$\frac{\text{Buffalo Mean Daily} + \text{Amherstburg Mean Daily}}{2} = \text{governing elevation}$$

1	2	3	4	5	6	7	8	9	10	11
Groups	Group	Days	Buffalo & Amherstburg Mean Daily	Multiplier	Weighted Elevations	C of G Elevs	Discharge	Multiplier	Weighted Discharge	C of G Discharge
6	XII	3	57255	3	171765		217767	3	653301	
19	XIII	13	57251	13	744263	572.354	202942	13	2,638,246	
6	I	5	57225	5	286125		194335	5	971,675	199868
8	III	6	57224	6	343344		193269	6	1,159,734	
8	IV	4	57200	4	228800	92	193238	4	772952	1220
6	II	6	572.12	6	343272	572.[illegible]	186567	6	1,119,[illegible]	190[illegible]
22	VII	10	572.03	10	5720.03		186405	10	1,864,050	
10	III	7	572.10	7	400470	905	184471	7	1,291,297	4986
11	X	6	571.78	6	343068	571[illegible]	184333	6	1,105,998	181[illegible]
5	IX	3	571.74	3	171522		183767	3	551,301	
6	VIII	4	571.72	4	228688		182688	4	730,752	
12	XI	7	571.67	7	400169		184511	7	1,291,577	
[illegible]										
		24			[illegible]				[illegible]	

572354
[illegible]
[illegible]
469

190882
[illegible] = [illegible] - 33145
449

190868
[illegible]
[illegible]
190882

$X = 33145\,Y - 18770769$

Williams Ex 34. Table XLVIb

Chicago Sanitary District.
Niagara Discharge

Amherstburg Mean Daily

1 Ft rise in Lake Erie

Sagitto	Group	Days	Amherstburg Mean Daily	Multiplier	Weighted Elevation	C of G Elevation	Discharge	Multiplier	Weighted Discharge	C of G Discharge
6	XII	3	572.46	3	171744		217767	3	653301	
19	XIII	13	572.46	13	744224	572.412	202942	13	2638246	199868
6	I	5	572.48	5	286240		194335	5	971675	
8	VI	6	572.51	6	3435.06		193285	6	1159734	
8	IV	4	571.91	4	2287.64	31	193238	4	772952	1220
6	II	6	572.41	6	343446	572.2[illegible]	186567	6	1119 402	196[illegible]
10	III	7	572.32	7	400624		184471	7	1291 297	
22	VII	10	572.13	10	572130		186405	10	1864050	
11	X	6	571.94	6	3431.64	101	184333	6	1105998	4996
12	XI	7	571.83	7	4002.81	572.[illegible]	184511	7	1291577	183[illegible]
5	IX	3	571.92	3	1715.76		183767	3	651301	
6	VIII	4	572.03	4	2288.12		182688	4	730752	
[illegible]										
		[illegible]			[illegible]				[illegible]	
					31				1220	
					572.2[illegible]				196[illegible]	

572.412 + 101/311

16882/311 = 97052

199868 + 4996/311 = 14882

Williams Ex 34

Chicago Sanitary District
Niagara Discharge

Table XLVII

Cleveland Mean Daily

1 Ft. rise in Lake Erie.

Year	Group	Days	Cleveland Mean Daily	Multiplier	Weighted Elevation	C of G of Elev.	Discharge	Multiplier	Weighted Discharge	C of G of Discharge
17	I	11	572.32	11	6291.72		206480	11	2271280	
11	VI	7	2.09	7	4004.63	572.127	192860	7	1350020	197229
22	II	11	1.97	11	6291.67		192710	11	2119810	
16	IV	6	1.74	6	3430.44	571.[illegible]	193650	6	1161900	[illegible]
22	VII	9	1.87	9	5146.83		186450	9	1678050	
14	III	5	1.69	5	2858.45		179500	5	897500	
2	VIII	8	1.62	8	4572.96	571.63	184360	8	1474880	183766
8	X	4	1.57	4	2286.28		180538	4	722150	
8	IX	4	1.51	4	2286.04		185100	4	740400	
[illegible]										

572.127
571.6[illegible]83 197229 [illegible] 3766
[illegible]
492 13463

Increment = 13463 / 492 = 30459 cu. ft. per sec.

Equation: 30459Y - 17229166
X - [illegible]

Williams Ex 34.

Chicago Sanitary District.
Niagara Discharge.

Table XLVII B

Cleveland Mean Daily

If rise in Lake Erie.

Engineer	Group	Days	Cleveland Mean Daily	Multiplier	Weighted Elevation	C of G Elevs	Discharge	Multiplier	Weighted Discharge	C of G Discharge
17	I	14	572.52	14	801528	572.068	206611	14	2892554	196,168
22	II	25	571.96	25	14299.00		192851	25	4821275	
11	VI	10	572.00	10	5720.00		191543	10	1915430	
14	IV	9	571.74	9	5145.66	205	194221	9	1747989	911
22	VII	10	571.84	10	5718.40	571	186405	10	1864050	190,918
8	IX	5	571.88	5	2857.90		186145	5	930725	
12	VIII	10	571.60	10	5716.00	570	185028	10	1850280	3,301
8	X	5	571.70	5	2858.50	571	181645	5	908225	185,329
14	III	10	571.80	10	5716.00		177878	10	1778780	
[illegible]										
		350			572068				19702311	

572.068
570
571
350

196,168
12858
196,168
12,007
12858

Williams Ex. 34

Table XLVIII
Sheet 1

Chicago Sanitary District
Precipitation

Superior : Marquette
Mich. Huron: Milwaukee, Detroit
Erie St. Clair : Detroit, Cleveland, Buffalo
Ontario : Buffalo, Oswego, Rochester, Toronto

Year	Superior	Mich. Huron	Erie-St. Clair	Ontario
1860	29.79	25.15	31.83	29.66
61	28.58	33.53	36.70	37.76
62	30.24	36.44	38.79	38.86
63	33.60	34.06	37.73	37.41
64	22.32	27.84	34.33	41.38
65	26.00	28.98	28.82	36.27
	28.83	30.58	33.04	37.24
1866	29.49	33.93	39.57	38.64
● 67		27.04	30.51	32.11
● 68		31.08	38.79	38.64
● 69		35.83	38.58	42.53
70		30.37	41.23	40.43
71		37.15	39.96	38.87
	29.49	31.58	36.57	37.75
1872	30.23	33.16	37.44	38.58
73	26.36	33.31	40.85	39.64
74	34.94	34.34	41.01	41.37
75	30.22	34.93	34.68	38.83
76	31.44	33.97	40.22	38.42
77	27.29	40.29	34.70	36.67
	28.46	33.50	35.61	33.05
1878	36.19	40.24	42.38	42.06
79	40.72	31.05	38.38	37.25
80	33.48	34.82	41.44	38.78
81	42.91	42.26	38.78	38.61
82	37.08	39.37	34.77	38.81
83	30.50	31.22	37.28	38.15
	36.81	39.36	40.16	36.12
1884	41.74	38.37	42.58	39.05
85	30.56	30.41	38.13	38.04
86	38.27	29.08	37.25	38.27
87	33.62	29.71	37.82	38.31
88	35.46	28.25	37.88	37.41 *
89	30.37	28.38	37.73	38.62
	32.11	28.33	33.49	32.45
1860-1889	31.71	32.35	35.77	35.32

* Toronto Missing
● Detroit taken as mean of Lansing and Monroe

Williams Ex. 34 Table XLVIII

Chicago Sanitary District Sheet 2

Precipitation

Superior : Marquette
Mich. Huron: Milwaukee, Detroit
Erie St. Clair : Detroit, Cleveland, Buffalo
Ontario : Buffalo, Oswego, Rochester, Toronto

Year	Superior	Mich-Huron	Erie-St.Clair	Ontario
1860-1889	31.71	32.35	35.77	35.32
1890	34.47	32.54	43.12	43.50*
91	33.78	29.35	37.45	37.82*
92	33.78	32.07	36.45	36.37*
93	35.68	35.85	38.43	38.31*
94	33.98	29.78	30.62	30.03
95	33.04	29.98	37.97	36.74
	33.34	31.36	34.75	36.01
1896	29.39	32.59	36.72	35.58
97	30.03	30.61	30.87	34.23
98	27.48	33.18	33.46	33.49
99	36.43	29.81	36.74	35.93
1900	32.32	30.77	31.01	35.20
11	37.15	29.44	34.33	37.49
	32.17	29.25	32.20	34.62
1903	26.77	32.08	36.11	32.89
03	35.84	32.64	36.41	34.42
04	33.74	29.00	36.91	36.47
05	28.18	27.03	33.25	34.68
06	37.43	34.33	32.97	32.73
07	31.62	32.76	33.25	33.05
	32.86	32.10	34.18	34.05
1908	30.29	28.43	30.74	31.32
09	29.27	28.08	37.27	34.23
10	30.24	25.04	33.65	31.73
11	37.22			34.00
12	30.35			32.41*
	31.38	29.19	33.67	34.23
1890-1907	32.79	30.90	33.71	34.90
1890-1908	32.66	30.77	33.53	34.71
1890-1910	32.39	30.66	33.71	34.80
1860-1908	32.12	31.74	34.90	35.08
1860-1910	32.02	31.69	34.93	35.11

* Toronto Missing

Williams Ex 34

Table XLVIII(a)
Sheet 1

Chicago Sanitary District
Annual Precipitation

Year	Annual Precipitation													
	Evanston	Lombard	Downers Grove	Florence	Wilmette	Chicago	Cicero	Blue Island	Buffalo Grove	Glenview	Barrington	Bensenville	Bromley
1860	23.79		28.77	30.40	22.02	(34.40)	37.18		30.03			30.38	28.00
61	30.98		37.59	31.78	33.48	(38.30)	33.90	40.67	38.61	32.05	44.59	33.99	34.45
62	30.24		31.43	33.46	41.45	(40.12)	38.29	44.65	30.67	32.05	44.59	40.21	34.05
63	33.60		30.57	32.29	33.16	(33.60)	34.67	33.92	29.15	30.16	44.79	31.22	32.77
64	22.32	27.95	29.88	29.01	29.50	(28.90)	33.18	37.17	40.96	43.79	43.97	40.24	30.94
65	26.08	29.92	27.10	30.82	31.86	(40.20)	32.02	39.55	33.53	43.37	43.29	33.77	32.93
66	29.49	30.62	31.72	29.67	34.18	(36.30)	38.65	40.67	38.96	43.29	46.03	30.07	39.42
67		24.98		32.97	24.10	22.41	31.13	31.36	31.44	33.22	31.66	31.66	30.11
68		30.10		32.68	29.27	30.98	33.82	42.16	38.54	42.51	39.22	34.28	34.38
69		32.04		30.36	31.51	30.57	37.86	42.44	40.68	47.08	44.35	39.64	39.64
1870		36.04	34.07	34.70	29.61	29.84	41.70		41.91	34.10	39.61	46.18	46.18
71		26.51	33.35	27.22	29.04	(33.61)	32.75	(36.08)	34.68	31.07	33.41	32.73	
72	(30.03)	27.74	32.11	24.74	(30.29)	31.22	36.31	(37.56)	28.57	31.74	(30.39)	25.35	
73	28.38	28.23	34.01	29.05	30.01	34.16	42.12	33.35	43.32	33.29	49.84	31.01	
74	24.04	23.09	26.69		31.00	29.32	33.91	22.81	30.41	34.91	35.51	24.34	
75	30.22		35.71		33.36	38.08	30.91	28.03	31.44	31.41	29.91	27.23	
76	31.44		40.40		30.34	30.51	41.70	34.35	39.25	34.19	33.82	31.41	
77	27.54		32.23		40.15	41.01	33.89	33.77	34.48	32.20	34.12	21.99	
78	36.19		41.39		33.89	41.35	33.51	37.61	60.24	35.83	40.80	40.35	

Continuation from Williams Exhibit 5 consisting of private data, Federal Office and Commission data.

Observations at Chicago 1871-1884 inclusive are from Chicago Weather Service Report, 1884, p. 5.

Observations at Chicago 1885-1891 inclusive are from Chicago Weather Service Report, 1891, p. 5.

Observations at Chicago 1892-1911 inclusive are from Chicago Weather Service Report, 1911, p. 5.

Observations at Chicago 1912-1916 inclusive are from Chicago Weather Service Report, 1916, p. 5.

Observations at Chicago 1917-1919 inclusive are from Chicago Weather Service Report, 1919, p. 5.

Observations at Chicago 1920-1922 inclusive are from Chicago Weather Service Report, 1922, p. 5.

Observations at Chicago 1923-1924 inclusive are from Chicago Weather Service Report, 1924, p. 5.

Observations at Chicago 1925-1926 inclusive are from Chicago Weather Service Report, 1926, p. 5.

Observations at Chicago 1927-1928 inclusive are from Chicago Weather Service Report, 1928, p. 5.

Observations at Chicago 1929-1930 inclusive are from Chicago Weather Service Report, 1930, p. 5.

Observations at Chicago 1931-1932 inclusive are from Chicago Weather Service Report, 1932, p. 5.

Observations at Chicago 1933-1934 inclusive are from Chicago Weather Service Report, 1934, p. 5.

Observations at Chicago 1935-1936 inclusive are from Chicago Weather Service Report, 1936, p. 5.

Observations at Chicago 1937-1938 inclusive are from Chicago Weather Service Report, 1938, p. 5.

Observations at Chicago 1939-1940 inclusive are from Chicago Weather Service Report, 1940, p. 5.

Observations at Chicago 1941-1942 inclusive are from Chicago Weather Service Report, 1942, p. 5.

Observations at Chicago 1943-1944 inclusive are from Chicago Weather Service Report, 1944, p. 5.

Observations at Chicago 1945-1946 inclusive are from Chicago Weather Service Report, 1946, p. 5.

Observations at Chicago 1947-1948 inclusive are from Chicago Weather Service Report, 1948, p. 5.

Observations at Chicago 1949-1950 inclusive are from Chicago Weather Service Report, 1950, p. 5.

Observations at Chicago 1951-1952 inclusive are from Chicago Weather Service Report, 1952, p. 5.

Observations at Chicago 1953-1954 inclusive are from Chicago Weather Service Report, 1954, p. 5.

Observations at Chicago 1955-1956 inclusive are from Chicago Weather Service Report, 1956, p. 5.

Observations at Chicago 1957-1958 inclusive are from Chicago Weather Service Report, 1958, p. 5.

Observations at Chicago 1959-1960 inclusive are from Chicago Weather Service Report, 1960, p. 5.

Observations at Chicago 1961-1962 inclusive are from Chicago Weather Service Report, 1962, p. 5.

Observations at Chicago 1963-1964 inclusive are from Chicago Weather Service Report, 1964, p. 5.

Observations at Chicago 1965-1966 inclusive are from Chicago Weather Service Report, 1966, p. 5.

Observations at Chicago 1967-1968 inclusive are from Chicago Weather Service Report, 1968, p. 5.

Observations at Chicago 1969-1970 inclusive are from Chicago Weather Service Report, 1970, p. 5.

Observations at Chicago 1971-1972 inclusive are from Chicago Weather Service Report, 1972, p. 5.

Observations at Chicago 1973-1974 inclusive are from Chicago Weather Service Report, 1974, p. 5.

Observations at Chicago 1975-1976 inclusive are from Chicago Weather Service Report, 1976, p. 5.

Observations at Chicago 1977-1978 inclusive are from Chicago Weather Service Report, 1978, p. 5.

Observations at Chicago 1979-1980 inclusive are from Chicago Weather Service Report, 1980, p. 5.

Observations at Chicago 1981-1982 inclusive are from Chicago Weather Service Report, 1982, p. 5.

Observations at Chicago 1983-1984 inclusive are from Chicago Weather Service Report, 1984, p. 5.

Observations at Chicago 1985-1986 inclusive are from Chicago Weather Service Report, 1986, p. 5.

Observations at Chicago 1987-1988 inclusive are from Chicago Weather Service Report, 1988, p. 5.

Observations at Chicago 1989-1990 inclusive are from Chicago Weather Service Report, 1990, p. 5.

Observations at Chicago 1991-1992 inclusive are from Chicago Weather Service Report, 1992, p. 5.

Observations at Chicago 1993-1994 inclusive are from Chicago Weather Service Report, 1994, p. 5.

Observations at Chicago 1995-1996 inclusive are from Chicago Weather Service Report, 1996, p. 5.

Observations at Chicago 1997-1998 inclusive are from Chicago Weather Service Report, 1998, p. 5.

Observations at Chicago 1999-2000 inclusive are from Chicago Weather Service Report, 2000, p. 5.

Observations at Chicago 2001-2002 inclusive are from Chicago Weather Service Report, 2002, p. 5.

Observations at Chicago 2003-2004 inclusive are from Chicago Weather Service Report, 2004, p. 5.

Observations at Chicago 2005-2006 inclusive are from Chicago Weather Service Report, 2006, p. 5.

Observations at Chicago 2007-2008 inclusive are from Chicago Weather Service Report, 2008, p. 5.

Observations at Chicago 2009-2010 inclusive are from Chicago Weather Service Report, 2010, p. 5.

Observations at Chicago 2011-2012 inclusive are from Chicago Weather Service Report, 2012, p. 5.

Observations at Chicago 2013-2014 inclusive are from Chicago Weather Service Report, 2014, p. 5.

Observations at Chicago 2015-2016 inclusive are from Chicago Weather Service Report, 2016, p. 5.

Observations at Chicago 2017-2018 inclusive are from Chicago Weather Service Report, 2018, p. 5.

Observations at Chicago 2019-2020 inclusive are from Chicago Weather Service Report, 2020, p. 5.

Observations at Chicago 2021-2022 inclusive are from Chicago Weather Service Report, 2022, p. 5.

Observations at Chicago 2023-2024 inclusive are from Chicago Weather Service Report, 2024, p. 5.

Observations at Chicago 2025-2026 inclusive are from Chicago Weather Service Report, 2026, p. 5.

Observations at Chicago 2027-2028 inclusive are from Chicago Weather Service Report, 2028, p. 5.

Observations at Chicago 2029-2030 inclusive are from Chicago Weather Service Report, 2030, p. 5.

Observations at Chicago 2031-2032 inclusive are from Chicago Weather Service Report, 2032, p. 5.

Observations at Chicago 2033-2034 inclusive are from Chicago Weather Service Report, 2034, p. 5.

Observations at Chicago 2035-2036 inclusive are from Chicago Weather Service Report, 2036, p. 5.

Observations at Chicago 2037-2038 inclusive are from Chicago Weather Service Report, 2038, p. 5.

Observations at Chicago 2039-2040 inclusive are from Chicago Weather Service Report, 2040, p. 5.

Observations at Chicago 2041-2042 inclusive are from Chicago Weather Service Report, 2042, p. 5.

Observations at Chicago 2043-2044 inclusive are from Chicago Weather Service Report, 2044, p. 5.

Observations at Chicago 2045-2046 inclusive are from Chicago Weather Service Report, 2046, p. 5.

Observations at Chicago 2047-2048 inclusive are from Chicago Weather Service Report, 2048, p. 5.

Observations at Chicago 2049-2050 inclusive are from Chicago Weather Service Report, 2050, p. 5.

Observations at Chicago 2051-2052 inclusive are from Chicago Weather Service Report, 2052, p. 5.

Observations at Chicago 2053-2054 inclusive are from Chicago Weather Service Report, 2054, p. 5.

Observations at Chicago 2055-2056 inclusive are from Chicago Weather Service Report, 2056, p. 5.

Observations at Chicago 2057-2058 inclusive are from Chicago Weather Service Report, 2058, p. 5.

Observations at Chicago 2059-2060 inclusive are from Chicago Weather Service Report, 2060, p. 5.

Observations at Chicago 2061-2062 inclusive are from Chicago Weather Service Report, 2062, p. 5.

Observations at Chicago 2063-2064 inclusive are from Chicago Weather Service Report, 2064, p. 5.

Observations at Chicago 2065-2066 inclusive are from Chicago Weather Service Report, 2066, p. 5.

Observations at Chicago 2067-2068 inclusive are from Chicago Weather Service Report, 2068, p. 5.

Observations at Chicago 2069-2070 inclusive are from Chicago Weather Service Report, 2070, p. 5.

Observations at Chicago 2071-2072 inclusive are from Chicago Weather Service Report, 2072, p. 5.

Observations at Chicago 2073-2074 inclusive are from Chicago Weather Service Report, 2074, p. 5.

Observations at Chicago 2075-2076 inclusive are from Chicago Weather Service Report, 2076, p. 5.

Observations at Chicago 2077-2078 inclusive are from Chicago Weather Service Report, 2078, p. 5.

Observations at Chicago 2079-2080 inclusive are from Chicago Weather Service Report, 2080, p. 5.

Observations at Chicago 2081-2082 inclusive are from Chicago Weather Service Report, 2082, p. 5.

Observations at Chicago 2083-2084 inclusive are from Chicago Weather Service Report, 2084, p. 5.

Observations at Chicago 2085-2086 inclusive are from Chicago Weather Service Report, 2086, p. 5.

Observations at Chicago 2087-2088 inclusive are from Chicago Weather Service Report, 2088, p. 5.

Observations at Chicago 2089-2090 inclusive are from Chicago Weather Service Report, 2090, p. 5.

Observations at Chicago 2091-2092 inclusive are from Chicago Weather Service Report, 2092, p. 5.

Observations at Chicago 2093-2094 inclusive are from Chicago Weather Service Report, 2094, p. 5.

Observations at Chicago 2095-2096 inclusive are from Chicago Weather Service Report, 2096, p. 5.

Observations at Chicago 2097-2098 inclusive are from Chicago Weather Service Report, 2098, p. 5.

Observations at Chicago 2099-2100 inclusive are from Chicago Weather Service Report, 2100, p. 5.

Williams Ex 34

Table XLVIII a
Sheet 2

Chicago Sanitary District
Annual Precipitation

Year	Annual Precipitation												Riverside
	Hegewisch	Lansing	Dentral	Monroe	Hinsdale	Chicago	Cleveland	Toledo	Buffalo	Conneaut	Rochester	Riverside	
1879	40.20		37.17		24.93	30.71	41.51	30.27	30.97	36.60	33.27	22.52	
1880	33.44		47.65		23.96	37.10	37.35	35.72	39.26	43.19	41.80	32.92	
81	42.91		43.44		39.07	44.19	34.96	45.91	34.93	39.23	38.24	21.19	
82	37.48		32.32		28.49	41.34	38.98	33.03	33.82	36.13	24.73	20.60	
83	30.30		32.57		23.47	43.86	41.13	34.24	36.07	34.49		23.81	
84	41.44		28.17		30.57	34.61	33.26	28.43	37.07	31.97	31.17	20.35	
85	(30.36)		28.94		32.38	44.57	38.93	33.9	32.36	33.14	28.31	26.35	
86	28.27		26.71		31.46	28.77	27.34	32.70	44.83	33.48	36.84	27.72	
87	25.62		28.97		30.90	29.13	34.36	32.01	31.33	23.41	28.30	17.91	
88	33.46		29.02		23.49	30.86	32.57	25.86	33.87	32.79	27.76		
89	30.31		21.06		31.70	34.35	32.57	21.84	40.07	40.10	33.70		
1890	34.47		34.99		30.09	32.69	41.82	33.61	40.35	40.86	43.09		
91	33.75		28.83		28.76	26.34	34.16	22.12	30.74	31.44	33.64		
92	27.28		37.11		33.09	30.36	36.51	36.70	40.57	34.81	33.02		
93	35.86		34.18		32.87	27.47	33.88	23.81	38.64	34.78	35.50		
94	33.50		23.74		27.79	27.46	27.73	21.34	38.92	36.44	30.11	29.64	
95	33.04		23.04		24.80	32.30	28.64	23.21	32.02	32.19	30.78	28.03	
96	28.39		30.20		28.95	33.14	36.68	33.10	37.29	38.32	36.84	29.08	
97	30.03		30.34		31.05	28.85	24.54	30.36	37.72	36.61	30.12	32.36	

Williams Ex. 34

Table XLVIIIa
Sheet 3

Chicago Sanitary District
Annual Precipitation

Year	Annual Precipitation													
	Marquette	Lansing	Detroit	Monroe	Milwaukee	Chicago	Cleveland	Toledo	Buffalo	Oswego	Rochester	Toronto		
1898	27.45		34.34		32.95	33.77	32.34	28.10	33.50	40.44	37.50	30.55		
1899	36.43		28.91		22.82	26.89	24.55	27.00	29.39	34.65	26.76	28.94		
1900	32.32		31.45		30.10	28.65	23.65	29.58	34.93	37.17	38.12	29.60		
01	37.19		28.78		18.11	24.32	38.71	26.29	33.49	43.08	37.20	32.19		
02	28.77		33.33		28.63	37.57	39.89	33.31	32.91	37.87	29.73	31.07		
03	39.84		35.88		33.41	28.09	33.41	35.08	37.93	39.63	29.44	30.63		
04	33.24		28.32		29.86	28.14	34.56	27.94	33.83	39.51	34.56	35.99		
05	28.16		32.00		32.19	33.36	31.90	28.39	33.85	38.10	33.50	31.28		
06	37.49		33.67		30.18	30.87	31.62	30.27	33.63	36.23	29.74	31.91		
07	31.68		30.62		34.90	33.10	34.76	35.03	34.97	38.36	27.60	31.42		
08	30.29		28.59		28.32	34.83	27.60	33.85	34.24	33.93	27.49	29.62		
09	29.27		40.63		31.31	43.72	34.29	40.42	36.86	37.59	29.50	32.92		
1910	30.54		24.98		21.10	28.86	33.65	29.13	42.45	36.99	33.52	33.78		
11	37.22		28.63		28.23	33.55	37.37	39.11	37.03	36.90	32.88	29.18		
12	30.59		29.66		34.59	29.67	33.94	31.95	33.22	40.36	29.45			

Williams Ex. 34. Table XLIX
Sheet 1

Chicago Sanitary District.

Elevations of Lake Ontario

1860-1889

Year	Full Year		Open Season	
	Elevation Water Surface	Mean of Period.	Elevation Water Surface	Mean of Period.
1860	246.96		247.10	
1	7.40		7.45	
2	7.43	247.20	8.00	247.43
3	7.19		7.39	
4	6.94		7.23	
5	6.89		6.92	
	1483.21		1484.59	
1866	246.13		246.57	
7	6.04		7.34	
8	5.83	246.47	5.90	246.80
9	6.35		6.92	
70	7.39		7.86	
1	6.10		6.40	
	1478.82		1480.78	
1872	244.82		245.00	
3	5.04		6.40	
4	6.36	245.92	6.69	246.22
5	5.87		5.37	
6	7.10		7.63	
7	5.99		6.08	
	1475.54	~	1477.35	
1878	246.30		246.69	
9	6.21		6.22	
80	5.89	246.22	6.00	246.45
1	6.31		5.76	
2	6.67		6.88	
3	6.26		7.16	
	1477.30		1478.71	
1884	247.30		247.55	
5	6.93		7.12	
6	7.60	246.77	7.71	246.98
7	7.02		7.30	
8	5.85		6.06	
9	6.53		6.17	
	1480.64		1481.89	
[illegible]	7395.91	246.52	7405.31	246.78

Williams Ex 34

Table XLIX
Sheet 2

Chicago Sanitary District

Elevations of Lake Ontario
1890-1912

Year	Full Year		Open Season	
	Elevation water surface	Mean of Period	Elevation water surface	Mean of Period
1890	247.07	245.77	247.31	245.99
1	6.12		6.12	
2	5.38		5.42	
3	5.98		5.98	
4	5.76		5.93	
5	4.29		4.35	
	1474.63		1475.94	
1896	244.62	243.05	244.86	243.28
7	4.87		5.12	
8	4.87		5.34	
9	5.10		5.30	
1900	5.13		5.18	
1	5.06		5.34	
	1470.30		1471.70	
1902	245.27	246.12	245.38	246.47
3	5.81		6.13	
4	6.64		7.31	
5	6.71		6.32	
6	6.03		6.10	
7	5.88		6.19	
	1476.70		1478.49	
1908	247.22	246.01	247.61	246.34
9	6.12		6.31	
10	5.61		5.95	
11	5.83		5.15	
12	6.02		6.47	
	1230.18		1231.70	
1890 to 1904	3682.71	245.514	3686.72	245.781
1890 to 1907	4421.63	245.646	4426.13	245.896
1890 to 1910	5160.71	245.748	5166.18	246.009
1890 to 1912	5631.81	246.731	5637.83	245.993
1890 to 1904	11078.71	246.183	11089.92	246.443
1890 to 1910	12336.71	246.700	12363.38	246.438
1890 to 1912	13047.32	246.176	13061.03	246.435

Williams Ex. 34. Table L
Sheet 1

Chicago Sanitary District

Elevations of Lake Superior

1860-1889

	Full Year		Open Season	
Year	Elevation of Water Surface	Mean for Period	Elevation of Water Surface	Mean for Period
1860 a	602.78		603.00	
1	2.83		3.10	
2	2.53		2.73	
3	2.19		2.27	
4	1.87		1.97	
5	2.25		2.63	
	3614.48	602.41	3615.70	602.62
1866 a	602.27		602.50	
7	2.49		2.69	
8	2.30		2.49	
9	2.63		2.98	
1870	2.32		2.48	
1	2.96		2.32	
	3614.97	602.50	3615.43	602.57
1872 b	602.03		602.26	
3	2.48		2.71	
4	2.56		2.71	
5	2.67		2.81	
6	3.06		3.35	
7	2.44		2.45	
	3615.24	602.54	3616.29	602.72
1878 b	601.87		601.88	
9	1.43		1.41	
1880	1.78		2.08	
1	2.21		2.35	
2	2.31		2.28	
3	2.01		2.12	
	3611.49	601.92	3612.12	602.02
1884 b	601.90		601.93	
5	2.18		2.29	
6	1.88		1.94	
	1805.90	601.97	1806.16	602.05
1887 b	601.88		602.02	
8	2.08		2.37	
9	2.14		2.27	
	1806.10	602.03	1806.26	602.09
1860-89	18068.18	602.273	18072.56	602.417

Williams Ex. 34. Table L

Sheet 2

Chicago Sanitary District

Elevations of Lake Superior

1890-1910

	Full Year		Open Season	
Year	Elevation of water surface	Mean for Period	Elevation of water surface	Mean for Period
1890 b	602.00		602.16	
1	1.69		1.78	
2	1.51		1.64	
3	1.86		2.14	
4	2.36		2.83	
5	2.62		2.73	
	3612.24	602.04	3613.30	602.22
1896 b	602.59		602.78	
7	2.00		2.79	
8	2.17		2.35	
9	2.69		2.97	
1900	2.77		2.85	
1	2.75		2.84	
	3615.57	602.60	3616.38	602.76
1902 b	602.53		602.66	
3 b/e	2.73		2.98	
4 b/e	2.71		2.84	
5 b/e	2.74		2.91	
6 b/e	2.63		2.71	
7 b/e	2.81		2.68	
8 b/e	2.27		2.43	
9 b/e	1.93		602.05	
1910 b/e	601.78		601.84	
	3421.83	602.43	3423.12	602.57
1890 to 1910	12649.64	602.364	12653.00	602.524
1860 to 1908	29314.11	602.33	29321.67	602.483
1860 to 1910	30717.82	602.310	30725.56	602.462

Williams Ex. 34 *Table L1*

Chicago Sanitary District

Elevation of Lakes
and Differences in Periods

1	2	3	4	5	6	7	8	9	10	11
Period	Superior	Huron-Mich.	Michigan-Huron	Huron-Mich.	St. Clair	St. Clair-Erie	Erie	Erie-Ontario	Ontario	Huron-Erie
1860-1899	602.41	2020	582.10	5.76	576.40	3.16	573.24	326.04	247.20	8.92
60 - 71	2.50	21.15	1.35	5.29	6.08	3.39	2.67	326.20	6.47	8.65
72 - 77	2.34	20.80	1.74	5.83	5.91	3.29	2.60	326.20	5.92	9.08
78 - 83	1.92	19.99	1.93	5.73	6.18	3.19	2.99	326.17	6.22	8.94
84 - 86	1.97	19.09	2.86	6.36	6.64	3.33	3.31	326.01	7.24	9.57
87 - 99	2.03	20.20	1.81	5.94	5.89	3.12	2.77	326.41	6.30	9.06
1860-1899	602.27	2036	581.91	5.75	576.16	3.24	572.92	326.16	246.52	8.99
90 - 95	602.04	21.51	580.53	5.41	575.12	3.00	572.12	326.35	245.77	8.41
96 - 01	2.80	22.42	0.41	3.35	4.53	3.04	1.79	326.34	5.03	8.39
02 - 04	2.66	22.19	0.47	5.21	5.26	3.02	2.24	326.33	5.93	8.21
05 - 10	2.31	21.36	0.75	5.36	5.35	3.06	2.31	325.98	6.33	8.44
1890-1910	602.30	21.83	580.49	5.35	575.13	3.04	572.10	326.16	245.75	8.36
1860-1910	602.31	20.99	581.32	5.58	575.74	3.16	572.58	326.16	246.20	8.74

Note: Mean Elevation of Ontario, 1860-1904 - 245.51, 1860-1901-246.18

Williams Ex. 34. Table LII

Chicago Sanitary District

Elevations and Differences of Elevation of the Great Lakes.

Full Year				Open Season			
Lake	1860 to 1889	1890 to 1910	Diff.	Lake	1860 to 1889	1890 to 1910	Diff.
	Elevations				Elevations		
Michigan Huron	581.91	580.48	1.43	Michigan Huron	582.10	580.70	1.40
St. Clair	576.16	575.13	1.03	St. Clair	576.41	575.36	1.05
Erie	572.92	572.10	0.82	Erie	573.16	572.35	0.81
Ontario	246.52	245.75	0.77	Ontario	246.78	246.01	0.77
		245.66*	0.86*			245.96*	0.82*
Differences.							
Huron to St. Clair	5.75	5.35	0.40	Huron to St. Clair	5.69	5.34	0.35
St. Clair to Erie	3.24	3.03	0.20	St. Clair to Erie	3.25	3.01	0.24
Huron to Erie	8.99	8.38	0.61	Huron to Erie	8.94	8.35	0.59
Erie to Ontario	326.40	326.35	0.05	Erie to Ontario	326.38	326.34	0.04
		326.44*	0.01*			326.46*	0.05*

* Elevation of Lake Ontario corrected for effect of Out Dam since 1905

Williams Ex 34

Chicago Sanitary District Dredging

Table LIII
Sheet 1

St. Clair River — Detroit River

Cubic yards Removed.

Date	St. Clair River and Lake St. Clair						Detroit River					
	Lower End Lake Huron	South Channel River	St. Clair River	St. Clair Flats Canal	Gross Reinf. Cur.	Total	Bailey Ave.	Lime Kiln Basin	Outer	Living Stone Chan.	Total	Grand Total.
1870				289756		289756						289756
71				40316		40316						40316
73		30000		10000		60000						60000
74		33074		214657		247731						247731
75		35000				35000						35000
76		6700				6700						6700
77		21796				21796		2632			2632	24428
78												
79								630			630	630
80				3626		3626		8401			8401	12027
81								17089			17089	17089
82								6797			6797	6797
83								6334			6334	6334
84								636			636	636
85								8369			8369	8369
86				64580		64580		13189			13189	79769
87								14698			14698	14698
88								1095			1095	1095
89		20800		50117		70917		8538			8538	85455
90		25439				25439		18344			18344	43783
91		17504		43496		61000		2797			2797	63797
92		40011		142765		182776						182976
		210344		841823		1113837		111769			111769	1225606

Cubic yards Removed

Williams Ex 34

Table LIII
Sheet 2

Chicago Sanitary District
Dredging

St. Clair River — Detroit River

Date	St. Clair River and Lake St. Clair						Detroit River					
	Lower End Lake Huron	South Black River	St. Clair Flats Canal	Gross Reinf. Curb	Total.	Bailed River	Lime Kiln Crossing	Outer	Living Stone Chan	Total.	Grand Total.
1893	3836		39517	104471	64984	140804			4677	4677	145541
94	29435		43837		539910	1202898			178565	178565	1381463
95	39401		120617		1805382	2349949	2230		460874	463104	2813053
96	10395				1870739	2731132	13867		332791	346158	2377290
97	3264	729			1219258	1252991	3174		40354	45528	1298119
98		45729	55379			101308	24620		89189	113809	215117
99			44636			44636	60035		14778	74813	121449
1900							26052	360		26412	26412
1			76258			76258	42354	30483	27507	100744	177002
2			86753			86753	77234	63791	105269	245694	332447
3		82368	60997			143966	70370	39020	174428	216484	360050
4	60312		337511	76469		469498	775	1570	26391	28736	518234
5	48350		328789		72374	444019		332264	631935	516421	960440
6			93848		41660	974128		113493	1104035	1217586	2251716
7		14405	78324			792969		86996	646390	733386	1526355
8		9101				9101		132640	2231132	2363772	2872873
9								54984	4390	59374	2922247
10									228946	228946	3151193
	107124	132135	3370128	8896	5644263	9344670	284479	5559639	39762	5883880	15228550
		270381		845513		1115837		111769		111769	1227606
	107124	402516	3370128	854409	5644263	10460507	284479	5671408	39762	5995650	16456156

1903 to 1910 14,975,331

Williams Ex. 34

Book LIV
Sheet 118

Chicago Sanitary District

Relative Fluctuation of Lakes

St. Clair - Erie.

Full Year

Year	Month	Group	Huron Elevation	St. Clair Elevation	St. Clair C of G	Erie Elevation	Erie C of G	St. Clair Change / Erie Change
1860	July	1	581.71	578.33	578.33	573.94	573.94	
	Aug.				0.00		0.00	
	Sept.							0.44 ÷ 0.44 = 100%
1861	July	2	581.32	576.32	578.23	573.71	573.71	
	Aug.		581.36	576.81	576.14	573.87	573.67	
	Sept.				0.91		0.20	0.21 ÷ 0.20 = 110%
1862	July	3	581.41	575.82	575.82	572.88	572.88	
	Aug.		581.49	575.84	575.84	572.83	572.83	
	Sept.				0.02		0.05	0.02 ÷ 0.05 = 120%
1863	July	4	581.36	576.42	576.42	573.32	573.32	
	Aug.		581.28	576.48	576.48	573.26	573.26	
	Sept.				0.06		0.06	0.22 ÷ 0.06 = 110%
1864	July	5	581.32	575.80	575.80	572.88	572.88	
	Aug.		581.32	575.82	575.82	572.83	572.83	
	Sept.				0.02		0.05	0.02 ÷ 0.05 = 57.75%
1865	July	6	581.24	575.79	575.79	572.84	572.84	
	Aug.		581.22	575.67	575.67	572.60	572.60	
	Sept.				0.12		0.24	0.12 ÷ 0.24 = 500%
1866	July	7	581.26	575.45	575.45	572.36	572.36	
	Aug.		581.22	575.43	575.43	572.31	572.31	
	Sept.				0.02		0.05	0.02 ÷ 0.05 = 40%
1867	July		581.26	574.97	574.97	572.25	572.25	
	Aug.		581.22	574.83	574.83	572.42	572.42	
	Sept.				0.14		0.17	0.14 ÷ 0.17 = 82.35%
1868	July		581.22	575.47	575.47	572.12	572.12	
	Aug.		581.11	575.38	575.38	571.98	571.98	
	Sept.				0.09		0.14	0.09 ÷ 0.14 = 64.28%
							1.06	0.32 ÷ 1.06 = 32.05%

Williams Ex 34

Table LIV
Sheet 2

Chicago Sanitary District

Relative Fluctuation of Lakes

St. Clair - Erie

Full Year

Year	Month	Group	Number Elevations	St. Clair		Erie		St. Clair Change / Erie Change
				Elevation	C. of G.	Elevation	C. of G.	
1872	Aug	8	38/04	575.77	575.77	573.03	573.03	
1873	May		1.03	3.62	579.39	2.36	575.39	
1874				3.52	582.91	2.64	578.03	
					0.21		0.30	0.21 - 33.25 %
1875	July	9	380.96	575.25	575.91	573.38	573.35	
1876	July			3.43	579.34	2.48	575.83	
1877	July			3.29	582.63	2.44	578.27	
1878	Aug			3.19	585.82	2.13	580.40	
1879	Nov			3.14	588.96	1.93	582.33	
					0.38		1.09	0.38 - 33.20 %
1880	Nov	10	380.88	575.54	575.52	573.04	573.76	
1881				3.33	578.85	2.71	576.47	
1882				3.33	582.18	2.56	579.03	
1883				3.24	585.42	2.33	581.36	
1884	June		0.88	3.28	588.70	1.72	583.08	
					0.19		0.79	0.19 - 24.05 %
1885	Aug	11	380.83	575.63	575.67	573.22	573.64	
1886	July			3.30	578.97	2.35	575.99	
1887				3.30	582.27	2.41	578.40	
1888	Nov			3.22	585.49	2.25	580.65	
1889	May		0.84	3.31	588.80	1.77	582.42	
					0.15		0.39	0.15 - 42.90 %
1890	Apr	12	380.78	575.71	575.55	573.28	573.70	
1891	Sept		0.80	3.29	578.84	2.39	576.09	
1892				3.30	582.14	2.38	578.47	
1893				3.30	585.44	2.35	580.82	
1901	May		0.81	3.33	588.77	1.31	582.13	
					0.16		1.12	0.16 - 69.60 %

Williams Ex. 34

Table LIV
Sheet 3

Chicago Sanitary District

Relative Fluctuation of Lakes

St. Clair - Erie

Full Year

Year	Month	Group	Huron Elevation	St. Clair		Erie		St. Clair Change Erie Change
				Elevation	C of S	Elevation	C of S	
1903	July	13	580.75	575.68	573.73	572.90	572.86	.835 - 88.60 %
1902	Aug.		.77	.78	573.72	.74		
1901	Sept.		.76	.86	573.72	1.71	572.33	1.37
					.015			
1896	June	14	580.72	575.55	573.67	572.81	572.60	.839 - 28.80 %
1895	July		.73	.60	573.66	.76		
1894	Aug.		.73	.53	573.65	.76	572.43	1.17
1893	Sept.		.73	.44	573.65	2.30		
			.73	.32	.014	1.54	572.09	.034
1923	June	15	580.67	575.78	573.54	573.26	572.72	.834 - 125.80 %
1922	July		.68	.81		.28		
1921	Aug.		.68	.33	573.53	2.27	572.33	1.39
1920	Sept.		.68	.26		1.97		
1919	Oct.		.67	.17	573.51		572.14	.138
					.015		.138	
1898	June	16	580.66	575.33	573.50	572.67	572.41	.826 - 32.10 %
1897	July		.66	.31		2.03		
1896	Aug.		.66	.07	573.11	1.36	571.87	1.33
1895	Sept.		.66	.04		1.33		
1894	Oct.		.66	.96	573.02		571.60	.881
					.026		.881	
1900	June	17	580.63	575.91	573.49	573.13	572.83	.826 - 41.70 %
1899	July		.63	.83		2.76		
1898	Aug.		.63	.54	573.35	2.42	572.50	1.33
1897	Sept.		.63	.20		2.31		
1896	Oct.		.63	.40		2.13		
1895	Nov.		.63	.18	573.24	2.09	572.33	.826
					.035		.826	

Williams Ex 34.

Table LIV
Sheet 4

Chicago Sanitary District
Relative Fluctuation of Lakes
St. Clair - Erie
Full Year

Year	Month	Group	Mean Elevation	St. Clair Elevations	St. Clair C.of G.	Erie Elevations	Erie C.of G.	Range
1898	June	18	580.56	576.53	576.53	573.03	572.57	
1899	July		580.56	576.53		572.78		
1899	Aug.		580.56	576.49		572.48		
1899	Sept.		580.56	576.50		572.43		
1901	Oct.		580.55	576.53		571.93		
	Nov.			576.54	576.51		571.46	1.13
				.17				
1902	June	19	580.51	576.54	576.36	572.36	572.34	
1899	July		0.53	5.03	5.18	2.31	2.01	
1898	Sept.		0.52	5.19	5.40	2.01	1.94	
1904	Oct.		0.56	5.40	5.53	1.94	1.77	
	Dec.			5.43		1.77		
				-0.17				0.45
1902	June	20	580.48	576.43	576.43	572.46	572.43	
1900	July		0.47	5.43	5.46	2.43	2.03	
	Aug.		0.46	5.46	5.48	2.29	1.98	
					0.05			0.45
1906	May	21	580.44	576.53	576.520	572.43	572.43	
1897	June		0.41	5.54	5.53	2.43	2.29	
1903	July		0.42	5.53	5.54	2.29	1.98	
1901	Aug.		0.43	5.55	5.481	1.72	1.78	
	Nov.			5.47		1.78		
				0.14	0.039		1.00	
1902	May	22	580.33	576.42	576.413	572.03	572.02	
1894	June		0.31	5.42	5.44	2.03	2.26	
1894	July		0.33	5.44	5.470	2.26	1.91	
1908	Aug.		0.38	5.50	5.52	1.91	1.52	
					0.039		1.24	
1903	May	23	580.27	Not given	Not given	(573.03)	(572.57	
1902	June		0.30	576.54	576.522	2.27	2.27	
1902	July		0.27	5.54	5.493	2.27	1.72	
1902	Aug.		0.28	5.44	5.476	1.38	1.45	
1902	Sept.		0.30	5.50		1.38		
1902	Oct.		0.29	5.51		1.36		
					0.046		0.90	

$\frac{1.13}{1.73} = 112.30\%$

$\frac{-0.17}{0.43} = -39.55\%$

$\frac{0.45}{0.88} = 39.40\%$

$\frac{0.45}{1.20} = 37.85\%$

$\frac{0.39}{1.24} = 30.22\%$

$\frac{0.90}{2.03} = 44.50\%$

Williams Ex 34 Chicago Sanitary District — Table LIV Sheet 3

Relative Fluctuation of Lakes

St Clair - Erie

Full Year

Year	Month	Basis	Hourly Fluctuations	St. Clair		Erie			St Clair - Erie Change
				Elevations	C & G S Datum	Elevations	C & G S Datum		
1900	Jan	24	3.0025	573.13	573.04	571.20	571.95		
1900	Feb		0.21	573.13	573.04	571.24	571.95		
1900	Mar		0.23	573.05	572.96	571.22	571.93		
1900	Apr		0.24	573.04	572.95	571.20	571.91		
1900	May		0.22	573.77	573.68	571.40	572.11		
1900				573.24	573.15	571.45	572.16		0.99 = 9120%
1901	Jan	25	3.0015	573.13	573.04	572.30	572.01		
1901	Feb		0.13	573.13	573.04	572.36	572.07		
1901	Mar		0.12	573.24	573.15	572.34	572.05		
1901	Apr		0.13	573.40	573.31	572.39	572.10		
1901	May		0.14	573.60	573.51	572.45	572.16		
1901			0.12	573.30	573.21	572.37	572.08		0.86 = 1945%
1902	Jan	26	3.0008	573.41	573.32	572.01	571.72		
1902	Feb		0.07	573.46	573.37	571.97	571.68		
1902	Mar		0.10	573.50	573.41	571.71	571.42		
1902	Apr		0.08	573.38	573.29	571.58	571.29		
1902	May		0.07	573.02	572.93	571.30	571.01		
1902				573.37	573.28	571.71	571.42		0.86 = 14430%
1903	Jan	27	3.0045	573.23	573.14	572.23	571.94		
1903	Dec		0.05	573.23	573.14	572.28	571.99		
1903				573.23	573.14	572.26	571.97		0.83 = -9333%
1904	Jan	28	3.0038	573.23	573.14	572.23	571.94		
1904			0.32	573.23	573.14	572.29	572.00		
1904			0.32	573.36	573.27	572.40	572.11		
1904			0.32	573.45	573.36	572.46	572.17		
1904			0.32	573.55	573.46	572.52	572.23		
1904			0.32	573.62	573.53	572.56	572.27		
1904				573.41	573.32	572.41	572.12		0.80 = 1720%

Williams Ex. 34.

Table LIV
Sheet 6

Chicago Sanitary District

Relative Fluctuation of Lakes

St. Clair - Erie

Full Year

Year	Month	Group	Huron Elevation	St. Clair Elevation	St. Clair C of G	Erie Elevation	Erie C of G	St. Clair Change / Erie Change
1918	Apr.	29	579.86	574.76	+374.11	571.39	+571.39	
1918	May		579.81	574.86		571.33		
1918	June		579.81	574.80		571.33		
1918	July		579.81	574.80		571.32		
1918	Aug.		579.81	574.80		571.31		
1918	Sept.		579.81	574.80		571.31		
1918	Oct.		579.81	574.80		571.31		
1918	Nov.		579.81	574.80		571.31		
1918	Dec.		579.81	574.80		571.31		
1919	Jan.		579.81	574.80		571.31		
1919	Feb.		579.81	574.80		571.31		
1919	Mar.		579.81	574.80		571.31		
1919	Apr.	30	579.81	574.83	+374.14	571.31	+571.36	
1919	May		579.86	574.87		571.36		
1919	June		579.86	574.90		571.36		
1919	July		579.86	574.90		571.36		
1919	Aug.		579.86	574.90		571.36		
1919	Sept.		579.86	574.90		571.36		
1919	Oct.		579.86	574.90		571.36		
1919	Nov.		579.86	574.90		571.36		
1919	Dec.		579.86	574.90		571.36		
1920	Jan.		579.86	574.90		571.36		
1920	Feb.		579.86	574.90		571.36		
1920	Mar.		579.86	574.90		571.36		
1920	Apr.	31	579.76	574.77	+374.11	571.33	+571.33	
1920	May		579.76	574.77		571.33		
1920	June		579.76	574.80		571.33		
1920	July		579.76	574.80		571.33		
1920	Aug.		579.76	574.80		571.33		
1920	Sept.		579.76	574.80		571.33		
1920	Oct.		579.76	574.80		571.33		
1920	Nov.		579.76	574.80		571.33		
1920	Dec.		579.76	574.80		571.33		
1921	Jan.		579.76	574.80		571.33		
1921	Feb.		579.76	574.80		571.33		
1921	Mar.		579.76	574.80		571.33		
1921	Apr.	32	579.72	574.16	+374.16	571.22	+571.22	
1921	May		579.74	574.23		571.22		
1921	June		579.73	574.23		571.22		
1921	July							
1921	Aug.							
1921	Sept.							
1921	Oct.							
1921	Nov.							
1921	Dec.							
1922	Jan.							
1922	Feb.							
1922	Mar.							
1922	Apr.	33	579.62	574.28	+374.20	571.23	+571.28	
1922	May		579.68	574.33		571.27		
1922	June		579.80	574.19		571.30		
1922	July							
1922	Aug.							
1922	Sept.							
1922	Oct.							
1922	Nov.							
1922	Dec.							
1923	Jan.							
1923	Feb.							
1923	Mar.							
1923	Apr.	34	579.54	574.48	+374.30	571.46	+571.56	
1923	May		579.54	574.63		571.46		
1923	June							
1923	July							
1923	Aug.							
1923	Sept.							
1923	Oct.							
1923	Nov.							
1923	Dec.							
1924	Jan.							
1924	Feb.							
1924	Mar.							
1924	Apr.	35	579.54	574.63	+374.51	571.46	+571.56	
1924	May		579.54	574.63		571.46		
1924	June							
1924	July							
1924	Aug.							
1924	Sept.							
1924	Oct.							
1924	Nov.							
1924	Dec.							
1925	Jan.							
1925	Feb.							
1925	Mar.							
1925	Apr.	36	579.54	574.63	+374.51	571.46	+571.56	
1925	May		579.54	574.63		571.46		
1925	June							
1925	July							
1925	Aug.							
1925	Sept.							
1925	Oct.							
1925	Nov.							
1925	Dec.							
1926	Jan.							
1926	Feb.							
1926	Mar.							
1926	Apr.	37	579.54	574.63	+374.51	571.46	+571.56	
1926	May		579.54	574.63		571.46		
1926	June							
1926	July							
1926	Aug.							
1926	Sept.							
1926	Oct.							
1926	Nov.							
1926	Dec.							
1927	Jan.							
1927	Feb.							
1927	Mar.							
1927	Apr.	38	579.54	574.63	+374.51	571.46	+571.56	
1927	May		579.54	574.63		571.46		
1927	June							
1927	July							
1927	Aug.							
1927	Sept.							
1927	Oct.							
1927	Nov.							
1927	Dec.							
1928	Jan.							
1928	Feb.							
1928	Mar.							
1928	Apr.	39	579.54	574.63	+374.51	571.46	+571.56	
1928	May		579.54	574.63		571.46		
1928	June							
1928	July							
1928	Aug.							
1928	Sept.							
1928	Oct.							
1928	Nov.							
1928	Dec.							
1929	Jan.							
1929	Feb.							
1929	Mar.							
1929	Apr.	40	579.54	574.63	+374.51	571.46	+571.56	
1929	May		579.54	574.63		571.46		
1929	June							
1929	July							
1929	Aug.							
1929	Sept.							
1929	Oct.							
1929	Nov.							
1929	Dec.							
1930	Jan.							
1930	Feb.							
1930	Mar.							
1930	Apr.	41	579.54	574.63	+374.51	571.46	+571.56	
1930	May		579.54	574.63		571.46		
1930	June							
1930	July							
1930	Aug.							
1930	Sept.							
1930	Oct.							
1930	Nov.							
1930	Dec.							
1931	Jan.							
1931	Feb.							
1931	Mar.							
1931	Apr.	42	579.54	574.63	+374.51	571.46	+571.56	
1931	May		579.54	574.63		571.46		
1931	June							
1931	July							
1931	Aug.							
1931	Sept.							
1931	Oct.							
1931	Nov.							
1931	Dec.							
1932	Jan.							
1932	Feb.							
1932	Mar.							
1932	Apr.	43	579.54	574.63	+374.51	571.46	+571.56	
1932	May		579.54	574.63		571.46		
1932	June							
1932	July							
1932	Aug.							
1932	Sept.							
1932	Oct.							
1932	Nov.							
1932	Dec.							
1933	Jan.							
1933	Feb.							
1933	Mar.							
1933	Apr.	44	579.54	574.63	+374.51	571.46	+571.56	
1933	May		579.54	574.63		571.46		
1933	June							
1933	July							
1933	Aug.							
1933	Sept.							
1933	Oct.							
1933	Nov.							
1933	Dec.							
1934	Jan.							
1934	Feb.							
1934	Mar.							
1934	Apr.	45	579.54	574.63	+374.51	571.46	+571.56	
1934	May		579.54	574.63		571.46		
1934	June							
1934	July							
1934	Aug.							
1934	Sept.							
1934	Oct.							
1934	Nov.							
1934	Dec.							
1935	Jan.							
1935	Feb.							
1935	Mar.							
1935	Apr.	46	579.54	574.63	+374.51	571.46	+571.56	
1935	May		579.54	574.63		571.46		
1935	June							
1935	July							
1935	Aug.							
1935	Sept.							
1935	Oct.							
1935	Nov.							
1935	Dec.							
1936	Jan.							
1936	Feb.							
1936	Mar.							
1936	Apr.	47	579.54	574.63	+374.51	571.46	+571.56	
1936	May		579.54	574.63		571.46		
1936	June							
1936	July							
1936	Aug.							
1936	Sept.							
1936	Oct.							
1936	Nov.							
1936	Dec.							
1937	Jan.							
1937	Feb.							
1937	Mar.							
1937	Apr.	48	579.54	574.63	+374.51	571.46	+571.56	
1937	May		579.54	574.63		571.46		
1937	June							
1937	July							
1937	Aug.							
1937	Sept.							
1937	Oct.							
1937	Nov.							
1937	Dec.							
1938	Jan.							
1938	Feb.							
1938	Mar.							
1938	Apr.	49	579.54	574.63	+374.51	571.46	+571.56	
1938	May		579.54	574.63		571.46		
1938	June							
1938	July							
1938	Aug.							
1938	Sept.							
1938	Oct.							
1938	Nov.							
1938	Dec.							
1939	Jan.							
1939	Feb.							
1939	Mar.							
1939	Apr.	50	579.54	574.63	+374.51	571.46	+571.56	
1939	May		579.54	574.63		571.46		
1939	June							
1939	July							
1939	Aug.							
1939	Sept.							
1939	Oct.							
1939	Nov.							
1939	Dec.							
1940	Jan.							
1940	Feb.							
1940	Mar.							
1940	Apr.	51	579.54	574.63	+374.51	571.46	+571.56	
1940	May		579.54	574.63		571.46		
1940	June							
1940	July							
1940	Aug.							
1940	Sept.							
1940	Oct.							
1940	Nov.							
1940	Dec.							
1941	Jan.							
1941	Feb.							
1941	Mar.							
1941	Apr.	52	579.54	574.63	+374.51	571.46	+571.56	
1941	May		579.54	574.63		571.46		
1941	June							
1941	July							
1941	Aug.							
1941	Sept.							
1941	Oct.							
1941	Nov.							
1941	Dec.							
1942	Jan.							
1942	Feb.							
1942	Mar.							
1942	Apr.	53	579.54	574.63	+374.51	571.46	+571.56	
1942	May		579.54	574.63		571.46		
1942	June							
1942	July							
1942	Aug.							
1942	Sept.							
1942	Oct.							
1942	Nov.							
1942	Dec.							
1943	Jan.							
1943	Feb.							
1943	Mar.							
1943	Apr.	54	579.54	574.63	+374.51	571.46	+571.56	
1943	May		579.54	574.63		571.46		
1943	June							
1943	July							
1943	Aug.							
1943	Sept.							
1943	Oct.							
1943	Nov.							
1943	Dec.							
1944	Jan.							
1944	Feb.							
1944	Mar.							
1944	Apr.	55	579.54	574.63	+374.51	571.46	+571.56	
1944	May		579.54	574.63		571.46		
1944	June							
1944	July							
1944	Aug.							
1944	Sept.							
1944	Oct.							
1944	Nov.							
1944	Dec.							
1945	Jan.							
1945	Feb.							
1945	Mar.							
1945	Apr.	56	579.54	574.63	+374.51	571.46	+571.56	
1945	May		579.54	574.63		571.46		
1945	June							
1945	July							
1945	Aug.							
1945	Sept.							
1945	Oct.							
1945	Nov.							
1945	Dec.							
1946	Jan.							
1946	Feb.							
1946	Mar.							
1946	Apr.	57	579.54	574.63	+374.51	571.46	+571.56	
1946	May		579.54	574.63		571.46		
1946	June							
1946	July							
1946	Aug.							
1946	Sept.							
1946	Oct.							
1946	Nov.							
1946	Dec.							
1947	Jan.							
1947	Feb.							
1947	Mar.							
1947	Apr.	58	579.54	574.63	+374.51	571.46	+571.56	
1947	May		579.54	574.63		571.46		
1947	June							
1947	July							
1947	Aug.							
1947	Sept.							
1947	Oct.							
1947	Nov.							
1947	Dec.							
1948	Jan.							
1948	Feb.							
1948	Mar.							
1948	Apr.	59	579.54	574.63	+374.51	571.46	+571.56	
1948	May		579.54	574.63		571.46		
1948	June							
1948	July							
1948	Aug.							
1948	Sept.							
1948	Oct.							
1948	Nov.							
1948	Dec.							
1949	Jan.							
1949	Feb.							
1949	Mar.							
1949	Apr.	60	579.54	574.63	+374.51	571.46	+571.56	
1949	May		579.54	574.63		571.46		
1949	June							
1949	July							
1949	Aug.							
1949	Sept.							
1949	Oct.							
1949	Nov.							
1949	Dec.							
1950	Jan.							
1950	Feb.							
1950	Mar.							
1950	Apr.	61	579.54	574.63	+374.51	571.46	+571.56	
1950	May		579.54	574.63		571.46		
1950	June							
1950	July							
1950	Aug.							
1950	Sept.							
1950	Oct.							
1950	Nov.							
1950	Dec.							
1951	Jan.							
1951	Feb.							
1951	Mar.							
1951	Apr.	62	579.54	574.63	+374.51	571.46	+571.56	
1951	May		579.54	574.63		571.46		
1951	June							
1951	July							
1951	Aug.							
1951	Sept.							
1951	Oct.							
1951	Nov.							
1951	Dec.							
1952	Jan.							
1952	Feb.							
1952	Mar.							
1952	Apr.	63	579.54	574.63	+374.51	571.46	+571.56	
1952	May		579.54	574.63		571.46		
1952	June							
1952	July							
1952	Aug.							
1952	Sept.							
1952	Oct.							
1952	Nov.							
1952	Dec.							
1953	Jan.							
1953	Feb.							
1953	Mar.							
1953	Apr.	64	579.54	574.63	+374.51	571.46	+571.56	
1953	May		579.54	574.63		571.46		
1953	June							
1953	July							
1953	Aug.							
1953	Sept.							
1953	Oct.							
1953	Nov.							
1953	Dec.							
1954	Jan.							
1954	Feb.							
1954	Mar.							
1954	Apr.	65	579.54	574.63	+374.51	571.46	+571.56	
1954	May		579.54	574.63		571.46		
1954	June							
1954	July							
1954	Aug.							
1954	Sept.							
1954	Oct.							
1954	Nov.							
1954	Dec.							
1955	Jan.							
1955	Feb.							
1955	Mar.							
1955	Apr.	66	579.54	574.63	+374.51	571.46	+571.56	
1955	May		579.54	574.63		571.46		
1955	June							
1955	July							
1955	Aug.							
1955	Sept.							
1955	Oct.							
1955	Nov.							
1955	Dec.							
1956	Jan.							
1956	Feb.							
1956	Mar.							
1956	Apr.	67	579.54	574.63	+374.51	571.46	+571.56	
1956	May		579.54	574.63		571.46		
1956	June							
1956	July							
1956	Aug.							
1956	Sept.							
1956	Oct.							
1956	Nov.							
1956	Dec.							
1957	Jan.							
1957	Feb.							
1957	Mar.							
1957	Apr.	68	579.54	574.63	+374.51	571.46	+571.56	
1957	May		579.54	574.63		571.46		
1957	June							
1957	July							
1957	Aug.							
1957	Sept.							
1957	Oct.							
1957	Nov.							
1957	Dec.							
1958	Jan.							
1958	Feb.							
1958	Mar.							
1958	Apr.	69	579.54	574.63	+374.51	571.46	+571.56	
1958	May		579.54	574.63		571.46		
1958	June							
1958	July							
1958	Aug.							
1958	Sept.							
1958	Oct.							
1958	Nov.							
1958	Dec.							
1959	Jan.							
1959	Feb.							
1959	Mar.							
1959	Apr.	70	579.54	574.63	+374.51	571.46	+571.56	
1959	May		579.54	574.63		571.46		
1959	June							
1959	July							
1959	Aug.							
1959	Sept.							
1959	Oct.							
1959	Nov.							
1959	Dec.							
1960	Jan.							
1960	Feb.							
1960	Mar.							
1960	Apr.	71	579.54	574.63	+374.51	571.46	+571.56	
1960	May		579.54	574.63		571.46		
1960	June							
1960	July							
1960	Aug.							
1960	Sept.							
1960	Oct.							
1960	Nov.							
1960	Dec.							
1961	Jan.							
1961	Feb.							
1961	Mar.							
1961	Apr.	72	579.54	574.63	+374.51	571.46	+571.56	
1961	May		579.54	574.63		571.46		
1961	June							
1961	July							
1961	Aug.							
1961	Sept.							
1961	Oct.							
1961	Nov.							
1961	Dec.							
1962	Jan.							
1962	Feb.							
1962	Mar.							
1962	Apr.	73	579.54	574.63	+374.51	571.46	+571.56	
1962	May		579.54	574.63		571.46		
1962	June							
1962	July							
1962	Aug.							
1962	Sept.							
1962	Oct.							
1962	Nov.							
1962	Dec.							
1963	Jan.							
1963	Feb.							
1963	Mar.							
1963	Apr.	74	579.54	574.63	+374.51	571.46	+571.56	
1963	May		579.54	574.63		571.46		
1963	June							
1963	July							
1963	Aug.							
1963	Sept.							
1963	Oct.							
1963	Nov.							
1963	Dec.							
1964	Jan.							
1964	Feb.							
1964	Mar.							
1964	Apr.	75	579.54	574.63	+374.51	571.46	+571.56	
1964	May		579.54	574.63		571.46		
1964	June							
1964	July							
1964	Aug.							
1964	Sept.							
1964	Oct.							
1964	Nov.							
1964	Dec.							
1965	Jan.							
1965	Feb.							
1965	Mar.							
1965	Apr.	76	579.54	574.63	+374.51	571.46	+571.56	
1965	May		579.54	574.63		571.46		
1965	June							
1965	July							
1965	Aug.							
1965	Sept.							
1965	Oct.							
1965	Nov.							
1965	Dec.							
1966	Jan.							
1966	Feb.							
1966	Mar.							
1966	Apr.	77	579.54	574.63	+374.51	571.46	+571.56	
1966	May		579.54	574.63		571.46		
1966	June							
1966	July							
1966	Aug.							
1966	Sept.							
1966	Oct.							
1966	Nov.							
1966	Dec.							
1967	Jan.							
1967	Feb.							
1967	Mar.							
1967	Apr.	78	579.54	574.63	+374.51	571.46	+571.56	
1967	May		579.54	574.63		571.46		
1967	June							
1967	July							
1967	Aug.							
1967	Sept.							
1967	Oct.							
1967	Nov.							
1967	Dec.							
1968	Jan.							
1968	Feb.							
1968	Mar.							
1968	Apr.	79	579.54	574.63	+374.51	571.46	+571.56	
1968	May		579.54	574.63		571.46		
1968	June							
1968	July							
1968	Aug.							
1968	Sept.							
1968	Oct.							
1968	Nov.							
1968	Dec.							
1969	Jan.							
1969	Feb.							
1969	Mar.							
1969	Apr.	80	579.54	574.63	+374.51	571.46	+571.56	
1969	May		579.54	574.63		571.46		
1969	June							
1969	July							
1969	Aug.							
1969	Sept.							
1969	Oct.							
1969	Nov.							
1969	Dec.							
1970	Jan.							
1970	Feb.							
1970	Mar.							
1970	Apr.	81	579.54	574.63	+374.51	571.46	+571.56	
1970	May		579.54	574.63		571.46		
1970	June							
1970	July							
1970	Aug.							
1970	Sept.							
1970	Oct.							
1970	Nov.							
1970	Dec.							
1971	Jan.							
1971	Feb.							
1971	Mar.							
1971	Apr.	82	579.54	574.63	+374.51	571.46	+571.56	
1971	May		579.54	574.63		571.46		
1971	June							
1971	July							
1971	Aug.							
1971	Sept.							
1971	Oct.							
1971	Nov.							
1971	Dec.							
1972	Jan.							
1972	Feb.							
1972	Mar.							
1972	Apr.	83	579.54	574.63	+374.51	571.46	+571.56	
1972	May		579.54	574.63		571.46		
1972	June							
1972	July							
1972	Aug.							
1972	Sept.							
1972	Oct.							
1972	Nov.							
1972	Dec.							
1973	Jan.							
1973	Feb.							
1973	Mar.							
1973	Apr.	84	579.54	574.63	+374.51	571.46	+571.56	
1973	May		579.54	574.63		571.46		
1973	June							
1973	July							
1973	Aug.							
1973	Sept.							
1973	Oct.							
1973	Nov.							
1973	Dec.							
1974	Jan.							
1974	Feb.							
1974	Mar.							
1974	Apr.	85	579.54	574.63	+374.51	571.46	+571.56	
1974	May		579.54	574.63		571.46		
1974	June							
1974	July							
1974	Aug.							
1974	Sept.							
1974	Oct.							
1974	Nov.							
1974	Dec.							
1975	Jan.							
1975	Feb.							
1975	Mar.							
1975	Apr.	86	579.54	574.63	+374.51	571.46	+571.56	
1975	May		579.54	574.63		571.46		
1975	June							
1975	July							
1975	Aug.							
1975	Sept.							
1975	Oct.							
1975	Nov.							
1975	Dec.							
1976	Jan.							
1976	Feb.							
1976	Mar.							
1976	Apr.	87	579.54	574.63	+374.51	571.46	+571.56	
1976	May		579.54	574.63		571.46		
1976	June							
1976	July							
1976	Aug.							

Williams Ex 34

Table LV
Sheet 1

Chicago Sanitary District
Relative Fluctuation of Lakes
St. Clair - Erie
Open Season, Apr - Nov Incl

Year	Month	Group	Huron Elev/Diff	St Clair Elev/Diff	C. & G. Diff	Erie Elev/Diff	C. & G. Diff	St Clair Change / Erie Change
1900	July	1	581.71	576.33	0.33	573.67	0.32	033 = 344%
1900	Aug		581.54	576.00		573.35		096
1900	Sept		581.38	575.91		573.27		
1905	July	2	581.55	576.25	0.24	573.41	0.24	044 = 417%.
1905	Aug		581.32	576.01		573.17		106
1905	Sept		581.36	575.95		573.07		
1902	August	3	581.44	575.83	0.24	572.96	0.24	044 = 1250%
1902	July		581.41	575.59		572.73		008
1902	Sept		581.43	575.84		572.83		
1907	June	4	581.42	576.19	0.24	573.40	0.24	044 = 4040%
1907	July		581.30	576.00		573.18		001
1907	Sept		581.30	575.90		573.16		
1903	July	5	581.32	575.92	0.24	572.88	0.24	044 = 5775%
1903	June		581.35	575.75		572.77		008
1903	Sept		581.30	575.80		572.80		
1906	July	6	581.32	575.88	0.24	572.84	0.24	044 = 5000%
1906	June		581.21	575.64		572.60		008
1906	Sept		581.20	575.69		572.36		
1904	June	7	581.09	575.92	0.24	573.25	0.24	044 = 3205%
1904	July		581.00	575.68		573.02		008
1904	Aug		581.02	575.44		572.78		

Weighted Mean of Relative Fluctuations = 1902% (See sheet 2)

Williams Ex 34.

Table L V.
Sheet 2

Chicago Sanitary District
Relative Fluctuation of Lakes.
St. Clair - Erie
Open Season, Apr. to Nov. inc.

Year	Month	Group	Huron Elevations	St. Clair		Erie		St. Clair Change
				Elevation	Col 6	Elevation	Col 6	Erie Change
1892	Aug.	8	581.04	575.77		573.03		
1893	Nov.		1.02	3.50		2.34		
1894				579.27	0.37		0.58	0.21 = 35.25 %
1895	July	9	580.32	579.95		573.38		
1896	July			576.45		573.33		
1897	July			579.91		573.46		
1898	Sept.			576.47		574.44		
1899	Sept.			579.79		574.13		
1900	Nov		0.83	575.33		572.20		
1901				579.27	0.38		1.08	0.38 = 35.20 %
1902	May	10	580.80	574.34		573.04		
1903	Sept.			576.88		574.11		
1904	Sept.			579.22		573.36		
1905	Sept.			575.42		573.36		
1906	Sept.			579.08		573.27		
1907	Nov.		0.80	575.33		571.71		
1908				579.12	0.79		0.79	0.79 = 24.05 %
1909	Aug.	11	580.83	575.65		572.72		
1910	July			576.90		573.68		
1911	July			579.57		574.17		
1912	Sept.			575.79		573.41		
1913	Sept.			579.49		574.29		
1914	Aug.		0.83	575.42		572.89		
1915				579.31	0.73		0.30	0.43 = 42.90 %
1916	Sept.	12	580.78	574.76		573.38		
1917	Sept.			576.80		574.26		
1918	Sept.			579.25		574.33		
1919	Nov.			575.79		573.31		
1920				579.30	0.80		1.23	0.43 = 65.04 %

Williams Ex. 84.

Table L V.
Sheet 3

Chicago Sanitary District
Relative Fluctuation of Lakes
St. Clair - Erie
Open Season Apr. to Nov. inc.

Year	Month	Group	Huron Elevation	St. Clair Elevation	St. Clair C of G	Erie Elevation	Erie C of G	St. Clair Change / Erie Change
1903	July	13	580.72	575.68	575.72	573.85	573.86	
1904	Oct.		8.98	3.78	3.84	1.87	1.80	2.04 = 54.54 %
					575.56		573.66	
					8.68		8.67	
1898	June	14	580.72	575.50	575.46	573.91	573.85	
1899	July		8.98	3.60	3.58	2.05	2.05	
1900	Aug.		8.72	3.38	3.39	1.83	1.83	
1903	Sept.		8.74	3.35	3.32	1.88	1.88	
1904	Oct.				575.32		573.68	
1905	Nov.				8.46		8.71	2.64 = 56.64 %
1898	Apr.	16	580.66	575.13	575.13	572.45	571.91	
1899	May		8.92	3.03	3.05	1.83	1.71	
1900	June		8.86	3.06	3.06	1.83	1.78	
1901	July		8.81	4.86	4.86	1.83	1.83	
1903	Aug.				574.94		571.41	2.48 = 56.00 %
1904	Sept.				8.76		8.50	
1905	Oct.				575.42		573.94	
1906	Nov.				8.54		8.53	
1898	Apr.	17	580.63	575.84	575.63	573.13	572.68	
1899	May		8.89	3.34	3.37	2.67	2.43	
1900	June		8.83	3.07	3.07	2.13	2.03	
1901	July		8.83	3.18	3.22	2.03	2.18	
1903	Aug.				575.22		572.43	2.79 = 59.75 %
1904	Sept.				8.45		8.18	
1905	Oct.				575.41		573.62	
1906	Nov.				8.33		8.11	
1898	June	18	580.58	575.33	575.33	573.08	572.59	
1899	July		8.84	3.28	3.28	2.53	2.21	
1900	Aug.		8.68	3.03	3.03	1.83	1.79	1.27 = 112.50 %
1901	Sept.		8.68	3.15	3.15	1.89	1.79	
1903	Oct.				574.93		572.21	
1904	Nov.				8.25		8.00	
1898	Apr.	21	580.44	575.23	575.23	573.03	572.58	
1899	May		8.71	3.23	3.23	2.53	2.38	
1900	June		8.43	3.07	3.02	1.78	1.78	1.15 = 37.50 %
					574.82		572.03	
					8.82		8.18	

Williams Ex. 34.

Table L.K.
Sheet 4

Chicago Sanitary District
Relative Fluctuation of Lakes
St. Clair - Erie
Open Season Apr. to Nov. inc.

Year	Month	Gage	Huron Elevation	St. Clair Elevation	St. Clair C of D	St. Clair Recession	Erie (573.00)	Erie C of D	St. Clair-Erie Change
1903	Apr.	23	580.27	Not Given	573.23			Not Given	
1902	May		0.30	573.21	573.10		2.29	573.72	
1901	Oct.		0.28	1.28	0.34		1.83	0.61	0.27 = 30.65%
1901	Apr.	24	580.25	573.43	573.43		572.20	573.20	
1902	May		0.27	1.21	572.92		1.30	0.30	
1899	Oct.		0.24	1.11	0.51		1.22	0.49	0.21 = 37.5%
1897	Apr.	23	580.14	573.13	573.04		572.30	572.30	
1902	May		0.14	1.20	572.93		1.39	0.39	
1902	Oct.		0.16	1.20	0.41		1.39	0.39	
1899	Nov.		0.18	1.20	573.34		1.39	571.91	
1880	July		0.18	1.25	0.31		1.48	571.62	0.28 = 46.6%
1900	Apr.	25	579.96	574.93	574.93		572.30	0.00	
1900	July		0.04	1.20	573.73		1.39	572.02	
1900	Sept.		0.04	1.20	574.66		1.39	571.30	
1891	Nov.		0.07	1.82	574.77		1.39	571.23	0.11 = 57.14%
					0.74			0.77	

Weighted Mean Recession of Erie = 1.39 ± 0.02 ft.

Williams Ex. 34. Table LVI

Chicago Sanitary District.

Winter Temperatures.

Closed Season; Dec-Mar. Incl.

Year	Detroit Fahrenheit	Buffalo Fahrenheit	Oswego Fahrenheit
1889-90	33.9	32.7	30.4
90-91	29.8	28.7	25.6
1-2	29.1	29.0	27.3
2-3	24.2	23.9	22.4
3-4	30.4	30.0	27.7
4-5	24.7	24.6	24.1
	28.7	28.2	26.3
1895-96	27.2	27.0	24.8
6-7	28.8	29.1	27.0
7-8	30.6	31.7	30.5
8-9	25.0	26.9	25.6
9-0	26.1	26.9	25.8
1900-01	26.0	27.1	25.1
	27.3	28.1	26.5
1901-02	28.0	28.8	27.5
02-03	29.6	31.1	28.7
03-04	22.3	23.5	21.2
04-05	25.4	23.6	21.8
05-06	29.9	29.6	27.9
06-07	28.9	26.7	26.0
	27.3	27.2	25.4
1907-08	28.6	28.4	27.1
08-09	30.1	29.6	28.0
09-10	28.6	28.6	27.8
10-11	28.3	27.3	25.3
11-12	22.9	24.6	24.1
	27.7	27.7	26.5

Williams Ex. 34 Table LVII

Chicago Sanitary District

Great Lakes Drainage Areas

Drainage Areas

River	Total Land & Lake Sq. Mi.	Total Lake Sq. Mi.	Total Land Sq. Mi.	Local Land & Lake Sq. Mi.	Local Lake	Local Land	Pop. per Sq. Mi. Local Land
St. Lawrence	287688	95088	192600	32980	7243	25737	534
Niagara	234708	67845	166863	34573	9968	24605	734
Detroit	220135	77877	142258	6194	303	5691	37
Niagara & Detroit	474843	163722	309121	40767	10471	30296	171
St. Clair	213941	77374	136567	137807	45314	92493	3338
Detroit & St. Clair	434076	155251	278825	144001	45817	98184	3375
St. Marys	76134	32060	44074	76134	32060	44074	2353

Table LVIII

Chicago Sanitary District

Comparisons of River Discharges

River	Discharges		Runoff per Square Mile				
			Total		Local		Stream
	Total C.F.S.	Local C.F.S.	Land and Lake C.F.S.	Land C.F.S.	Land and Lake C.F.S.	Land C.F.S.	C.F.S.
	By Complainant's Equation 1900-1907						
St. Lawrence	247762	47690	0.86	1.29	1.45	1.35	1.44
Niagara	200072	6344	0.78	1.20	0.19	0.27	0.86
St. Clair	193528	115328	0.90	1.42	0.84	1.25	0.87
St. Mary's	78200	78200	1.03	1.77	1.03	1.77	
	By E.S. Wheeler Rep. 1882-1898 Rep. Ch. Eng. 1908						
St. Lawrence	249075	31973	0.87	1.29	0.97	1.24	
Niagara	217102	24391	0.85	1.30	0.71	1.00	
St. Clair	192511	122148	0.90	1.41	0.89	1.32	
St. Mary's	70363	70363	0.92	1.60	0.92	1.60	
	By International Waterways Comm. 1890-1904						
St. Lawrence	233320	34812	0.81	1.21	1.06	1.35	
Niagara	198507	12207	0.78	1.19	0.35	0.80	
Detroit	186300	110920	0.85	1.31	0.77	1.13	
St. Mary's	75380	75380	0.99	1.71	0.99	1.71	

Williams Ex. 34. Table LIX o

Chicago Sanitary District

Runoff From Drainage Basins

By Local Stream Gagings

Month	C.F.S. Per Square Mile		
	Huron-Michigan	Erie	Ontario
January	0.779	1.023	1.480
February	0.858	0.912	1.446
March	1.377	2.101	2.435
April	1.735	1.199	3.162
May	1.177	0.613	2.005
June	0.930	0.566	1.254
July	0651	0.303	0.881
August	0.515	0.168	0.735
September	0.515	0.139	0.648
October	0.591	0.126	0.912
November	0.635	0.207	1.116
December	0.629	0.605	1.201
Full Year	0.866	0.664	1.440
Apr.-Nov Inc.	0.844	0.415	1339
June-Nov "	0.640	0.252	0.924

Williams Ex 34. Table LIX

Chicago Sanitary District

Runoff from Huron-Michigan Drainage

Summary

Huron-Michigan Drainage

Drainage	January		February		March		April		May		June	
	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Lake Michigan	157613	69777	139995	69721	172357	216373	191163	327868	190457	217301	185291	189339
Lake Huron	28709	20488	23868	19689	23582	61895	34244	65338	34244	46933	34244	28949
Total	186322	90265	163864	89410	202139	278268	225407	393206	224701	264234	229535	218288
C.F.S./Sq.Mi.		0.779		0.858		1.377		1.735		1.177		0.930

Drainage	July		August		September		October		November		December	
	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Lake Michigan	189971	104383	189313	102965	202356	103388	202356	120956	189320	121002	183774	120637
Lake Huron	34244	17988	31783	15993	33208	16218	33208	18866	35669	22066	32819	18795
Total	224215	122371	221096	118960	236164	121606	236166	139822	225189	143068	221993	139432
C.F.S./Sq.Mi.		0.631		0.545		0.515		0.591		0.635		0.629

Williams Ex. 34. Chicago Sanitary District Table LIXc
Sheet 1
Runoff from Lake Michigan Drainage (14 Sheets)

Summary
Lake Michigan Drainage

Drainage	River	Year	January		February		March		April		May		June	
			Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Lake Michigan	Escanaba	1903-09							3200	15378	3200	11002	4800	7887
"	Fox	1895-04	35800	24954	53800	25738	62000	29674	62000	108002	62000	50867	62000	52513
"	Grand	1897-09	33900	57738	33900	71412	33900	113666	28900	96031	28800	60465	28800	50719
"	Iron	1900-02	75	64	75	62	130	144	130	282	130	194	130	134
"	Kalamazoo	1901-07	8824	7870	8824	7400	8824	14258	10295	12793	10295	9103	10295	8229
"	Manistee	1903-09	5400	6280	5400	5783	5400	7079	5400	10480	5400	8750	5400	6840
"	Menominee	1898-09	9975	9910	9975	5700	9975	9970	13872	33333	18304	42913	20724	32464
"	Muskegon	1901-06	4702	2937	7054	4202	9406	9333	9406	9673	9406	8643	9406	6288
"	Oconto	1906-09	1628	610	1628	626	1628	217	1628	2210	1628	2680	2442	2195
"	St. Joseph	1901-06	13745	17424	13745	17949	19680	34525	23615	33606	19680	19737	19680	15319
"	Wolf	1907-09	1394	930	1394	847	1394	1039	797	1360	1394	2930	1394	1709
		Totals	157643	124717	139779	139721	172557	216513	191163	322868	190457	217301	195291	184339
		C.F.S. per Sq. Mi.		0.792		0.873		1.255		1.689		1.140		0.944

Williams Ex 34

Chicago Sanitary District

Table L IXc
Sheet 2

Runoff from Lake Michigan Drainage

Summary
Lake Michigan Drainage

Drainage	River	Year	July		August		September		October		November		December	
			Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.
Lake Michigan	Escanaba	1903-09	4800	3000	4800	2385	5800	3483	5400	5311	5400	3827	5200	3074
"	Fox	1885-04	2000	1200	2000	1192	2300	1776	2300	2793	2300	2445	2300	2436
"	Grand	1891-09	3800	3148	3800	2725	3800	2545	3800	3245	3800	3004	3800	3220
"	Iron	1900-02	130	116	130	99					79	72	79	89
"	Kalamazoo	1901-04	4275	681	4275	3889	4275	614	4275	6006	4275	6735	4275	735
"	Manistee	1903-09	6300	7218	6300	6769	6300	6740	6300	6894	6300	7257	6300	718
"	Menominee	1885-09	2400	1601	2400	2045	2487	2144	2487	2534	2012	2017	2640	1587
"	Muskegon	1901-06	1405	1206	1758	343	1758	1068	1758	612	1758	645	1758	686
"	Ocanto	1906-09	342	1737	342	1033	342	1337	342	1303	342	1737	428	600
"	St. Joseph	1901-06	1800	3510	1576	1809	1800	942	1800	1638	1800	2740	1800	1796
"	Wolf	1907-09	1394	1733	1394	1238	1394	1460	1394	1307	1394	1218	1394	1200
		Totals	31711	24050	31584	22446	32487	23144	32487	23534	32012	30171	32640	25087
		Run-off		0.872		0.59		0.59		0.496		0.638		0.637

Williams Ex. 34

Table LIXc
Sheet 3

Chicago Sanitary District

Runoff from Lake Michigan Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Sanitary	Canals	43 G.S. 43 "29	1903											800	1571
"	"	"	1904											800	1512
"	"	" 770	1905							800	2468	800	2322	800	1730
"	"	" 726	1906							800	5170	800	1870	800	1160
"	"	" 744	1907							800	2420	800	4390	800	1100
"	"	" 744	1908							800	3320	800	2420	800	839
"	"	" 781	1909							3200	17745	3200	11062	800	1887
											4.81		3.44		1.441
River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Sanitary	Canals	43 G.S. 43 "29	1903	800	663	800	454	800	1617	800	1625	800	985		
"	"	" 770	1904	800	669	800	565	800	741	800	1145	800	657		
"	"	" 726	1905	800	669	800	411	800	708	800	623	800	699	800	491
"	"	" 744	1906	800	579	800	413	800	714	800	485	800	1000	800	964
"	"	" 744	1907	800	351	800	406	800	779	800	829	800	544	800	446
"	"	" 781	1908	800	617	800	342	800	220	800	294	800	243		
"	"		1909	800	734	800	2538	800	274	800	310	800	891	800	773
				4800	3856	4800	2538	5600	5383	5600	5311	5600	5019	3200	3674
					.804		.341		.908		.948		.897		.961

Williams Ex 34

Table L
Sheet

Chicago Sanitary District

Runoff from Lake Michigan Drainage

Lake Michigan Discharge

River	Location	Authority	Year	January	February	March	April	May	June
				Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.
Fox	Chicago Drainage Canal	U.S.G.S. W.S.P. 345	1895	6300 3531	6300 4320	6300 3417	6300 6540	6300 3610	6300 4700
"	"	"	1896		6300	6300 1894	6300 918	6300 3140	6300 3776
"	"	"	1897	6300 2102	6300 2705	6300 2711	6300 6432	6300 406	6300 3916
"	"	"	1898	6300 2249	6300 2239	6300 2968	6300 4091	6300 1743	6300 3110
"	"	"	1899	6300 1405	6300 2013	6300 2222	6300 3337	6300 609	6300 638
"	"	"	1900	6300 2174	6300 2847	6300 2705	6300 344	6300 2576	6300 810
"	"	"	1901	6300 3316	6300 3773	6300 3639	6300 2960	6300 1194	6300 3173
"	"	"	1902	6300 2263	6300 2142	6300 2982	6300 2235	6300 1435	6300 1810
"	"	"	1903	6300 1740	6300 2249	6300 3827	6300 6300	6300 5537	6300 3041
"	"	"	1904	6300 2677	6300 3301	6300 3138	6300 6444	6300 5707	6300 4482
				July	August	September	October	November	December
River	Location	Authority	Year	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.	Area Disch. Sq. Mi. C.F.S.
Fox	Chicago Drainage Canal	U.S.G.S. W.S.P. 345	1895	6300 7612	6300 4428	6300 3808	6300 3417	6300 2007	6300 2361
"	"	"	1896	6300 2787	6300 1410	6300 446	6300 1065	6300 892	6300 2314
"	"	"	1897	6300 3300	6300 891	6300 533	6300 1434	6300 892	6300 2314
"	"	"	1898	6300 1571	6300 187	6300 188	6300 1701	6300 2213	6300 2175
"	"	"	1899	6300 3196	6300 1306	6300 308	6300 1144	6300 2118	6300 2087
"	"	"	1900	6300 358	6300 189	6300 2271	6300 3220	6300 4062	6300 4533

Williams Ex. 34

Table LIX c
Sheet 5

Chicago Sanitary District

Runoff from Lake Michigan Drainage

River	Location	Authority	Year	July.		August.		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Fox	Bridge Above Dam.	U.S. Eng. Rpt.	1901	600	3301	600	2178	600	1721	600	2351	600	3286	600	2768
"	"	"	1902	600	4304	600	2856	600	1766	600	1818	600	2294	600	2774
"	"	"	1903	600	4124	600	3446	600	4321	600	4588	600	3696	600	2785
"	"	"	1904	600	3105	600	2085	600	1434	600	3411	600	4078	600	3348
				2400	12916	2400	10286	2400	9326	2400	12163	2400	12424	2400	11675
					241		339		286		419		532		.445
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Grand	Grand Rapids	U.S. Eng. Rpt.	1897									400	2892	400	1761
"	"	"	1898	400	3007	400	2892			400	4815	400	2203	400	1735
"	"	"	1899	400	6965	400	4773	400	3649	400	10708	400	3088	400	2236
"	"	"	1900	400	2520	400	2324	400	3545	400	1991				
"	"	Sylvania Electric	1901	400	2230	400	2102	400	13564	400	6076	400	3344	400	2613
"	"	"	1902	400	6530	400	3340	400	8140	400	4730	400	1412	400	3652
"	"	"	1903	400	4418	400	2383	400	12830	400	8818	400	3344	400	2821
"	"	"	1904	400	3449	400	3418	400	3044	400	6530	400	4091	400	2719
"	"	"	1905	400	8288	400	6991	400	6963	400	6116	400	3359	400	4412
"	"	"	1906	400	2300	400	1270	400	4080	400	9300	400	6344	400	3860
"	"	"	1907	400	2300	400	1270	400	4080	400	9300	400	6344	400	3860

Williams Ex 34

Table LI
Sheet

Chicago Sanitary District

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Grand	Grand Rapids	U.S.G.S.	1908	4300	4714	4300	6534	4300	17430	4300	8314	4300	3574	4300	4328
"	"	Mich. Public Service Co.	1909	3960	3753	3960	7282	3960	19225	3960	7685	3960	2210	3960	3079
					1.071		1.325		2.10		1.637		1.079		.863
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Grand	Grand Rapids	U.S.G.S. W.S.P.	1897	4300	692	4300	571	4300	1370	4300	1181	4300	1453	4300	2382
"	"	"	1898	4300	1491	4300	861	4300	1694	4300	1853	4300	2645	4300	3614
"	"	"	1899	4300	1719	4300	1617	4300	1741	4300	1715	4300	1795	4300	2059
"	"	"	1900												
"	"	Grd. Rapids Power Co.	1901	4300	4266	4300	2087	4300	2015	4300	2318	4300	2258	4300	3221
"	"	"	1902	4300	6085	4300	2908	4300	3187	4300	3330	4300	4419	4300	4525
"	"	"	1903	4300	2675	4300	2361	4300	1791	4300	5118	4300	2999	4300	3308
"	"	"	1904	4300	1835	4300	1438	4300	2282	4300	3210	4300	1815	4300	2079
"	"	"	1905	4300	4254	4300	3230	4300	3055	4300	3366	4300	3835	4300	3350
"	"	"	1906	4300	1821	4300	1574	4300	1391	4300	2015	4300	3344	4300	4112
"	"	"	1907	4300	2867	4300	2179	4300	2432	4300	2820			4300	3567
"	"	"	1908	4300	2710	4300	2096	4300	3220	4300	2498	4300	2811	4300	2713
"	"	"	1909	4300	1910	4300	1370	4300	1120	4300	1428	4300	2507	4300	4419
				3960	3753	3960	7282	3960	19225	3960	7685	3960	4419	3960	3726
				4300	1071	4300	1325	4300	2110	4300	1637	4300	1079	4300	863

Williams Ex 34

Table LIXc
Sheet 7

Chicago Sanitary District

Runoff from Lake Michigan Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S.	Area Sq Ft	Discharge C.F.S	Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S
Iron	Iron River	U.S.G.S. W.S. 97	1900												
"	"	"	1901	75	64	75	62	75	67	75	169	75	94	75	73
			1902					75	77	75	93	75	100	75	81
				75	64	75	62	150	144	150	262	150	194	150	154
					.854		.827		.960		1.346		1.291		1.027

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S
Iron	Iron River	U.S.G.S. W.S. 97	1900												
"	"	"	1901	75	116							79	72	79	69
			1902	75	60	75	59								
				150	176	75	59					79	72	79	69
					1.172		.786						.911		.814

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq Mi	Discharge C.F.S	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.
Kalamazoo	Allegan	U.S.G.S. W.S. 83	1901	1471	881	1471	683	1471	932	1471	940	1471	776	1471	837
"	"	"	1902	1471	1308	1471	1704	1471	2700	1471	812	1471	816	1471	828
"	"	"	1903	1471	1308	1471	1704	1471	2700	1471	2399	1471	1118	1471	1094
"	"	"	1904	1471	1215	1471	1443	1471	3007	1471	3062	1471	1513	1471	1019

Chicago Sanitary District

Runoff from Lake Michigan Drainage

Table LI
Sheet

Lake Michigan Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.
Nippersink Lake	Antioch	U.S.G.S. W.S. #270	1905	1411	976	1411	880	1411	849	1411	1120	1411	1020	1411	1060
"	"	" #308	1906	1410	1810	1410	1810	1410	1740	1410	1930	1410	1740	1410	1610
"	"	" #44	1907	1410	1920	1410	1320	1410	1700	1410	2230	1410	1530	1410	1110
				2824	7650	2824	7400	2824	4428	2820	6299	2820	5105	2820	5824
					382		309		1016		1493		1806		1989
River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.	Area Sq.mi.	Discharge C.F.S.
Nippersink Lake	Antioch	U.S.G.S. W.S. #8	1901	1411	722	1411	768	1411	741	1411	741	1411	847	1411	799
			1902	1411	918	1411	797	1411	761	1411	900	1411	923	1411	938
			1903	1411	908	1411	1012	1411	1236	1411	1158	1411	1008	1411	1171
			1904	1411	973	1411	911	1411	894	1411	1046	1411	894	1411	827
			1905	1411	1392	1411	957	1411	938	1411	924	1411	1093	1411	1130
			1906	1410	844	1410	808	1410	996	1410	977	1410	1100	1410	1270
			1907	1410	894	1410	736	1410	828	1410	1000	1410	1020	1410	1340
				11295	6781	11295	5899	11295	6114	11295	6906	11295	7395	11295	7515
					599		511		594		830		960		715

Williams Ex 34

Chicago Sanitary District — Table LIXc, Sheet 9

Runoff from Lake Michigan Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Hanisville	Sherman	U.S.G.S. W.S. Pap.	1904	900	1100	900	1000	900	1100	900	1200	900	1740	900	1240
"	"	"	1905	900	901	900	855	900	1000	900	1080	900	1310	900	1120
"	"	"	1906	900	1200	900	1100	900	1110	900	1240	900	1320	900	1060
"	"	"	1907	900	1140	900	900	900	1040	900	1420	900	1370	900	1240
"	"	"	1908	900	943	900	910	900	1230	900	1330	900	1330	900	1080
"	"	"	1909	900	996	900	1110	900	993	900	1320	900	1620	900	1100
				5400	6080	5400	5765	5400	7075	5400	10080	5400	8720	5400	6840
					1101		1067		1340		1940		1618		1267
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Hanisville	Sherman	U.S.G.S. W.S. Pap.	1903	900	1040	900	1200	900	1200	900	1150	900	1100	900	1210
"	"	"	1904	900	1050	900	999	900	942	900	1010	900	926	900	910
"	"	"	1905	900	1110	900	952	900	934	900	943	900	1080	900	1000
"	"	"	1906	900	1000	900	920	900	878	900	905	900	1000	900	1000
"	"	"	1907	900	936	900	944	900	971	900	1030	900	1030	900	1200
"	"	"	1908	900	1030	900	892	900	843	900	885	900	908	900	945
"	"	"	1909	900	982	900	891	900	935	900	898	900	973	900	993
				6300	7218	6300	6765	6300	6746	6300	6944	6300	7037	6300	7185
					1145		1074		1070		1086		1120		1130

Williams Ex 34. *Table LIIc*
Sheet 10

Chicago Sanitary District

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Authority	Year	February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Hennepin Canal	Lower Summit Reach	U.S.E.D. H.D. 83	1898					2432	4011	2432	3080	2432	2459
"	Iron Mt.	U.S.E.D. W.S. 129	1899					2415	3175	2415	7496	2415	3417
"	"	"	1902					2415	3995	2415	7879	2415	4791
"	"	"	1903					2415	3282	2415	6810	2415	3011
"	"	"	1904					2415	8040	2415	5610	2415	3040
"	"	U.S.E.D. W.S. 336	1905	2415	2370	2415	2250	2415	7050	2415	7920	2415	3040
"	"	"	1906	2415	2370	2415	2250	2415	7050	2415	7920	2415	3040
"	"	"	1907	3780	1980	3780	1800	3780	7050	3780	7920	3780	3040
"	Rock	"	1908	3780	1980	3780	1800	3780	7050	3780	7920	3780	3040
"	"	"	1909	3780	1260	3780	1310	3780	1820			2430	3230
"	Iron Mt.	"	1909										
"	Rock	"	1909	9975	9910	9975	3100	9975	3970	15872	33695	48304	42913	20224	32461
					392		511		2981		2111		2341		1568

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Hennepin Canal	Lower Summit Reach	U.S.E.D. H.D. 83	1898	2432	1139	2432	2282	2432	2366	2432	3248	2432	2166		
"	Iron Mt.	U.S.E.D. W.S. 129	1899	2432	1819	2432	1573								
"	"	U.S.E.D. W.S. 336	1902					2415	1735	2415	1596	2415	2829	2415	1909
"	"	"	1903	2415	3393	2415	1049	2415	2091	2415	1057	2415	2505	2415	2150

Chicago Sanitary District Table LIXc Sheet 11

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Menominee.	Iron Mt.	U.S.G.S. W.S. #129	1904	2415	2196	2415	2125	2415	2488	2415	3650	2415	2293	2415	1838
"	" "	" #156	1905	2415	3850	2415	2130	2415	3284	2415	2163	2415	2704	2415	2043
"	" "	" #206	1906	2415	3500	2415	2400	2415	2160	2415	2140				
"	Koss	" #244	1907	3780	3220	3780	2170	3780	4240	3780	2860	3780	2430	3780	2350
"	"	" "	1908	3780	3740	3780	2100	3780	1440	3780	2200	3780	1880	3780	2270
"	Iron Mt.	" #264	1909	2420	2740	2420	1920	2420	1580	2420	1400	2420	3270	2420	2480
"	" "	" "		24504	26057	24504	20749	24487	24144	24487	28314	22072	20177	19640	15082
					1.069		.846		.985		.951		.914		.769

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Muskegon.	Newaygo	U.S.G.S. W.S. #129	1901											2352	1073
"	"	"	1902	2352	717	2352	773	2352	1348	2352	2430	2352	3149	2352	1809
"	"	"	1903			2352	1579	2352	3715	2352	3244	2352	2153		
"	"	"	1904												
"	"	" #170	1905					2352	2812	2352	2129	2352	2091	2352	2286
"	"	" #206	1906	2350	2220	2350	1830	2350	1480	2350	1810	2350	1250	2350	1120
				4702	2937	7054	4202	9406	9355	9406	9673	9406	8643	9406	6288
					.625		.596		.995		1.028		.919		.669

Williams Ex. 34 Chicago Sanitary District Table LIXC
Sheet 12

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Aumsville	Year	July		August		September		October		November		December	
				Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.
Hudson	Nawanga	USGS WS 29	1901	2332	1064	2332	939	2332	886	2332	1175	2332	898	2332	904
			1902	2332	1488	2332	1085	2332	1078	2332	1572	2332	1338	2332	1281
			1904			2332	1015	2332	778	2332	1061	2332	993	2332	920
			1905	2332	1284	2332	1082	2332	1129	2332	1154	2332	1266	2332	1161
			1906	2350	1080	2350	914	2330	997	2330	1250	2330	1900	2330	1920
				9400	4900	11738	3415	11738	4866	11738	6212	11738	6433	11736	6186
					321		456		414		329		349		320
River	Location	Aumsville	Year	January		February		March		April		May		June	
				Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.	Area Sq.mi.	Discharge c.f.s.
Ohio	Gilbert	USGS WS 34	1906							814	1160	814	1230	814	776
			1907							814	1120	814	1450	814	575
			1908	814	317	814	337	814	486	814	1120	814	1450	814	575
			1909	814	293	814	289	814	331						
				1628	610	1628	626	1628	817	1628	2210	1628	2680	2442	2195
					374		364		301		1338		1815		899

Williams Ex. 34. Chicago Sanitary District Table LIXc Sheet 13.

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Oconto	Gillett	U.S.G.S. W.S. #244	1906	814	504	814	501	814	570	814	682	814	957		
"	"	"	1907	814	520	814	291	814	682	814	474	814	476	814	331
"	"	"	1908	814	733	814	261	814	285	814	347	814	364	814	275
				2442	1757	2442	1053	2442	1537	2442	1503	2442	1797	1628	606
					.720		.431		.630		.616		.736		.372
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
St. Joseph	Berrien	U.S.G.S. W.S. #89	1901							3935	3074	3935	2790	3935	2057
"	"	"	1902	3935	2721	3935	2446	3935	5197	3935	3560	3935	3863	3935	3629
"	"	" #89	1903	3935	4450	3935	3973	3935	8084	3935	6933				
"	"	"	1904	3935	5853	3935	5830	3935	12010	3935	8801	3935	3744	3935	2669
"	"	" #110	1905					3935	4784	3935	4688	3935	6080	3935	3534
"	"	" #208	1906	3940	4400	3940	3700	3940	4390	3940	4330	3940	3060	3940	3460
				15745	17424	15745	17949	19680	34525	23615	33606	19680	19737	19680	15349
					1.106		1.14		1.751		1.421		1.002		.780

Williams Ex 34.

Table LIXc
Sheet 14

Chicago Sanitary District.

Runoff from Lake Michigan Drainage

Lake Michigan Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
St Joseph	Buchanan	U.S.G.S. W.S. 385	1901	3935	1730	3935	1507	3935	1774	3935	2804	3935	2785	3935	3220
"	"	"	1902	3935	4947	3935	2377	3935	2268	3935	3791	3935	3284	3935	3714
"	"	"	1904	3935	2639			3935	1292	3935	1870	3935	1844	3935	1594
"	"	"	1905	3935	2994	3935	2015	3935	2308	3935	2223	3935	2617	3935	3035
"	"	"	1906	3940	1780	3940	2030	3940	1300	3940	1470	3940	2370	3940	4170
				19880	13410	15745	7909	19680	9147	19680	11638	19700	12740	19680	15796
					687		502		465		592		648		803
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Wolf	Kesherra	U.S.G.S. W.S. 384	1907									797	1630	797	796
"	"	"	1908	797	510	797	399	797	608	797	1360	797	1300	797	911
"	"	"	1909	797	420	797	448	797	431						
				1594	930	1594	847	1594	1039	797	1360	1594	2930	1594	1709
					583		531		652		1.71		1.85		1.071
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Wolf	Kesherra	U.S.G.S. W.S. 384	1907	797	811	797	694	797	988	797	685	797	640	797	600
"	"	"	1908	797	942	797	564	797	472	797	612	797	578	797	450
				1594	1753	1594	1238	1594	1460	1594	1307	1594	1218	1594	1030
					1.10		.789		.915		.820		.764		.638

Williams Ex. 34

Table LIX d
Sheet 1
5 Sheets

Chicago Sanitary District

Runoff from Lake Huron Drainage

Summary
Lake Huron Drainage

Drainage	River	Year	January		February		March		April		May		June	
			Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.
Lake Huron	Au Sable	1902-08	4260	4340	1420	1830	4270	5083	8335	13284	8335	10993	8335	9682
"	Cass	1908-09	863	193	863	818	1726	7600	863	1500	863	1400	863	140
"	Thunder Bay	1901-06	8320	4093	8320	4541	8320	9987	10080	20016	10080	11945	10080	7796
"	Tittabawassee	1903-09	14766	10860	14766	12490	14766	31925	14766	33838	14766	22593	14766	11831
		Totals	28109	20486	25869	19689	29582	61875	34244	68938	34244	46933	34244	29949
		C.F.S. per Sq. Mi.		0.714		0.761		2.092		2.003		1.373		0.845
			July		August		September		October		November		December	
Drainage	River	Year	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.	Area Sq. Mi.	Disch. in c.f.s.
Lake Huron	Au Sable	1902-08	8335	7337	8335	7311	9960	8026	9960	8099	9960	8685	7110	7364
	Cass	1908-09	863	109	863	819	863	401	863	334	863	472	863	780
	Thunder Bay	1901-06	10080	3003	10080	4320	10080	3564	10080	4717	10080	3667	10080	4873
	Tittabawassee	1903-09	14766	5339	12305	3722	12305	4538	12305	6017	14766	7667	14766	6279
		Totals	34244	17788	31783	15492	33208	16218	33208	18866	35669	22006	32819	18795
		C.F.S. per Sq. Mi.		0.525		0.487		0.488		0.568		0.619		0.572

Williams Et. al. vs. Chicago Sanitary District

Table LIX d Sheet 2

Runoff from Lake Huron Drainage

Lake Huron Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Au Sable	Bamfield	U.S.G.S. W.S. #29	1903					1425	2030	1425	1938	1425	1380	1425	1117
"	"	"	1904							1425	2698	1425	2142	1425	1506
"	"	" #110	1905					1425	1703	1425	1478	1425	1631	1425	1379
"	"	" #206	1906	1420	1270	1420	1850	1420	1350	1420	2780	1420	1610	1420	1570
"	"	" #244	1907	1420	2090					1420	2550	1420	2280	1420	2450
"	"	"	1908	1420	1180					1420	2440	1420	1950	1420	1660
				4260	4540	1420	1850	4270	5083	8533	13384	8533	10993	8533	9857
					1.06		1.30		1.19		1.57		1.29		1.13

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Au Sable	Bamfield	U.S.G.S. W.S. #29	1902					1425	1008	1425	1067	1425	1352	1425	1299
"	"	"	1903	1425	1124	1425	1465	1425	1436	1425	1228	1425	1107		
"	"	"	1904	1425	1290	1425	1212	1425	1108	1425	1175	1425	1094		
"	"	" #110	1905	1425	1133	1425	1134	1425	1114	1425	1069	1425	1202	1425	1175
"	"	" #206	1906	1420	1320	1420	1210	1420	1120	1420	1180	1420	1580	1420	2660
"	"	" #244	1907	1420	1370	1420	1140	1420	1210	1420	1260	1420	1280	1420	1170
"	"	"	1908	1420	1300	1420	1150	1420	1060	1420	1170	1420	1130	1420	1260
				8535	7337	8535	7311	9960	8036	9960	8099	9960	8685	7110	7561
					.883		.856		.808		.813		.870		1.06

Williams Ex. 34

Table LIXd

Chicago Sanitary District. Sheet 3

Runoff from Lake Huron Drainage

Lake Huron Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.
Cass	Frankfort	U.S.G.S. W.S. 284	1908	863	193	863	818	863	3910	863	1300	863	1400	863	140
"	"	"	1909	863	193	863	818	1776	7600	863	1300	863	1400	863	140
					2.24		.948		4.40		1.74		1.62		.162
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.
Cass	Frankfort	U.S.G.S. W.S. 284	1908	863	109	863	819	863	40.1	863	33.4	863	47.2	863	78.8
				863	109	863	819	863	40.1	863	33.4	863	47.2	863	78.8
					.126		.095		.0465		.0387		.0546		.0913
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.	Area Sq Mi.	Discharge C.F.S.
Huron Bay	Alpena	U.S.G.S. W.S. 85	1901	1260	344	1260	306	1260	1237	1260	2987	1260	1236	1260	736
"	"	"	1902	1260	365	1260	699	1260	2117	1260	1089	1260	1111	1260	810
"	"	"	1903	1260	478	1260	574	1260	900	1260	1482	1260	792	1260	331
"	"	"	1904	1260	497	1260	431	1260	1268	1260	1391	1260	2254	1260	474
"	"	"	1905	1260	936	1260	919	1260	1323	1260	1911	1260	1262	1260	905
"	"	"	1906	1260	936	1260	919	1260	1323	1260	3297	1260	1551	1260	723

Williams Ex 34

Table 1

Chicago Sanitary District.

Runoff from Lake Huron Drainage

Lake Huron Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Thunder Bay.	Alpena	U.S.G.S. W.S. "214	1907	1260	1321	1260	833	1260	1840	1260	1629	1260	1686	1260	1136
			1908	1260	564	1260	699	1260	1310	1260	3275	1260	2053	1260	961
				8820	4395'	8820	4541'	8820	9887.	10080	20018	10080	11945	10080	7296
					.555'		.515'		1.12		1.99		1.19'		.725

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Thunder Bay.	Alpena	U.S.G.S. W.S. "83	1901	1260	673	1260	611	1260	684	1260	788	1260	700	1260	536
"	"	"	1902	1260	699	1260	689	1260	183	1260	559	1260	925	1260	483
"	"	"	1903	1260	616	1260	1038	1260	1002	1260	868	1260	546	1260	480
"	"	"	1904	1260	461	1260	461	1260	428	1260	476	1260	444	1260	441
"	"	"	1905	1260	492	1260	479	1260	371	1260	440	1260	633	1260	559
"	"	"	1906	1260	812	1260	409	1260	247	1260	631	1260	1125	1260	982
"	"	"	1907	1260	523	1260	451	1260	466	1260	442	1260	633	1260	669
"	"	"	1908	1260	727	1260	222	1260	183	1260	513	1260	661	1260	703
				10080	5003'	10080	4340'	10080	3364'	10080	4717	10080	5667'	10080	4873'
					.497'		.431'		.334'		.468'		.562'		.484'

Williams Ex. 34

Table LIX d
Sheet 5

Chicago Sanitary District.

Runoff from Lake Huron Drainage

Lake Huron Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Thornton Reservoir	Freeland	G.S.W. Report	1904	2461	856	2461	1100	2461	600	2461	3364	2461	2300	2461	1305
"	"	"	1905	2461	740	2461	852	2461	4341	2461	3423	2461	4639	2461	4445
"	"	"	1906	2461	3340	2461	4745	2461	9011	2461	3339	2461	2083	2461	1125
"	"	"	1907	2461	3332	2461	2079	2461	6890	2461	3090	2461	3139	2461	1931
"	"	"	1908	2461	1054	2461	1157	2461	8373	2461	5302	2461	4865	2461	2873
"	"	"	1909.	2461	1788	2461	2317	2461	4700	2461	6724	2461	3019	2461	2149
				14766	10800	14766	12400	14766	39825	14765	33698	14766	22395	14766	11834
					.735		.845		2.46		2.28		1.53		.801
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Thornton Reservoir	Freeland	G.S.W. Report	1903			2461	*843	2461	1518	2461	2236	2461	1183	2461	801
"	"	"	1904	2461	774	2461	690	2461	615	2461	903	2461	667	2461	609
"	"	"	1905	2461	1334	2461	981	2461	1034	2461	1232	2461	1795	2461	1220
"	"	"	1906	2461	732							2461	2429	2461	2040
"	"	"	1907	2461	884	2461	633	2461	803	2461	853	2461	1180	2461	840
"	"	"	1908	2461	832	2461	825	2461	983	2461	703	2461	731	2461	783
"	"	"	1909	2461	873										
				14766	3339	12305	3722	12305	4238	12305	6017	14765	7697	14760	6279
					.361		.302		.371		.489		.520		.420

*10days

Williams Ex 34

Table LIX
Sheet 1
(7 Sheets)

Chicago Sanitary District

Runoff from Lake Erie Drainage

Summary

Lake Erie Drainage

Drainage	River	Year	January		February		March		April		May		June	
			Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Lake Erie	Black	1905 - 06	834	1134	417	269	1251	2825	1251	1457	1251	7018	1668	10716
"	Cuyahoga	1903 - 03	1396	992	1396	657	1396	4730	1396	2231	1396	4599	1396	1627
"	Huron	1904 - 09	3780	2819	4342	3236	4342	7085	4342	3708	4342	14771	4342	5973
"	Maumee	1898 - 06	20373	21152	21023	18891	21023	32744	21023	23612	21023	123141	21023	13312
"	Sandusky	1894 - 00	1532	2178	1532	1525	1532	3278	1532	1286	1532	715	1532	370
"	Thames	1894-97					1228	789	1228	817	3604	2267	3604	2132
"	Tiffin	1903-05					1496	3017	1496	2672	1496	1782	2744	1866
	Totals		26404	27273	27744	24601	34651	61519	34651	43595	35204	157172	37012	37901
	Other Sq. Mi.				1293	2182		2182		1749		2871		2360
			July		August		September		October		November		December	
Drainage	River	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Lake Erie	Black	1905 - 06	1668	3942	1251	4328	1251	1492	1251	1392	1251	2378	1251	341
"	Cuyahoga	1903-03	1396	992	1396	657	1396	414	2234	1036	2004	1015	695	762
"	Huron	1904-09	4342	2227	3789	831	3785	814.6	3789	1010	3785	1382	3028	1339
"	Maumee	1898-06	21081	7844	20903	2820	20903	7137	20903	1130	24901	4208	20834	16317
"	Sandusky	1894-00	1532	111	1532	287	1532	41	1532	19	770	54	1532	896
"	Thames	1894-97	3604	1369	1228	345			2436	1119				
"	Tiffin	1903-03	2744	431	2744	4348	2744	128.7	2744	3042	2744	5347	1496	871
	Totals		40173	18768	36537	13718	34111	10722	40008	8698	40811	15005	29465	20239
	Other Sq. Mi.			2308		2308		2308		2178		2308		2225

Williams Ex 34

Chicago Sanitary District

Runoff from Lake Erie Drainage

Table LIXe
Sheet 2

Lake Erie Drainage

River	Location	Authority	Year	January			February			March			April			May			June		
				Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches
Black	Elyria	U.S.G.S.	1903																		
"	"	"	1904	417	608	1.68	417	869	2.39	417	1210	3.32	417	676	1.86	417	227	.62	417	536	1.47
"	"	"	1905							417	799	2.19	417	571	1.57	417	440	1.21	417	300	.82
"	"	"	1906	417	346	.95				417	616	1.69	417	410	1.13	417	409	1.12	417	206	.57
				834	1154		417	869	12.51	1251	3325	12.51	1251	1457	12.51	1251	1076	12.51	1251	1042	12.51
					1.38			2.08			2.10			1.16			.86			.83
				July			August			September			October			November			December	
River	Location	Authority	Year	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches	Area Sq.Mi.	Discharge C.F.S.	Depth in Inches
Black	Elyria	U.S.G.S.	1903	417	94	.26	417	272	.75	417	82	.23	417	95	.26	417	48	.13	417	174	.48
"	"	"	1904	417	255	.71	417	68.8	.19	417	11	.03	417	12.1	.03	417	75.1	.21	417	45	.12
"	"	"	1905	417	16.5	.05	417	112	.31	417	36.2	.10	417	32.1	.09	417	94.7	.26	417	319	.88
"	"	"	1906	417	28.7	.08															
				1668	394.2	12.51	1251	452.5	12.51	1668	129.2	12.51	1251	139.2	12.51	1251	237.8	12.51	1251	541	12.51
					.236			.362			.119			.111			.190			.432	

Williams Ex 34

Table LIXe
Sheet 3

Chicago Sanitary District

Runoff from Lake Erie Drainage

Lake Erie Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.
Chicago Drainage Canal	Robey Street	U.S.E.S. Ill. 1929 - 170	1903					698	2342	698	641	698	959	698	1094
			1904					698	2408	698	596	698	740	698	533
			1905					1396	4750	1396	2237	1396	1439	1396	817
									340		150		122		117
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.
Chicago Drainage Canal	Robey Street	U.S.E.S. Ill. 1929 - 170	1903	698	546	698	285	698	927	698	472	698	337		
			1904	698	416	698	329	698	467	698	104	698	109		
			1905	1396	992	1396	657	1396	1414	2094	1036	2094	1018	698	782
					711		492		101		495		486		109
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.	Area Sq.Mi.	Disch. Cu.Ft.S.
Huron	Gelden	U.S.E.S. Ill. 1929 - 170	1904			757	525	757	2387	757	1684	757	458	757	394
			1905	757	204	757	170	757	750	757	646	757	606	757	1106
			1906	757	696	757	426	757	515	757	620	757	454	757	322
			1907	757	980	757	386	757	720	757	859	757	604	757	410
			1908	757	479	757	965	757	2065	757	877	757	627	757	246

Williams Ex 34.

Table LIX a
Sheet 4

Chicago Sanitary District
Runoff from Lake Erie Drainage

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.
Huron	Chicago	U.S.E.D. H.S. 1924	1909	757	302	757	524	757	663	757	494	757	1130	757	485
				3785	2845	4542	3296	4542	7095	4542	5202	4542	4277	4542	2923
					751.		.726		1.56		1.145		.941		.644
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.
Huron	Chicago	U.S.E.D. H.S. 1924	1904	757	169	757	180	757	250	757	290	757	239		
			1905	757	399										
			1906	757	145	757	156	757	836	757	139	757	272	757	447
			1907	757	240	757	138	757	221	757	316	757	362	757	452
			1908	757	96	757	269	757	143	757	141	757	153	757	237
			1909	757	175	757	114	757	114	757	124	757	356	757	409
				4542	1227	3785	857	3785	811.6	3785	1010	3785	1382	3028	1539
					.270		.226		.214		.267		.365		.507
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.	Area Sq.Mi.	Disch. Sec.Ft. C.F.S.
Missis-sippi	Mississ. Hdw.	U.S.E.D. Rep. 1911	1898	6111	10979	6111	6301	6111	9989	6111	6028	6111	9950	6111	1057
			1899	6111	5054	6111	7946	6111	5810	6111	11439	6111	9355	6111	3449
			1900	6111	2309	6111	5716	6111	1207	6111	3646	6111	9147	6111	3599
			1901												

Williams Ex. 34 Chicago Sanitary District Table LIXE Sheet 5

Runoff from Lake Erie Drainage

Lake Erie Drainage

River	Location	Authority	Year	January Area Sq Mi.	January Discharge C.F.S.	February Area Sq Mi.	February Discharge C.F.S.	March Area Sq Mi.	March Discharge C.F.S.	April Area Sq Mi.	April Discharge C.F.S.	May Area Sq Mi.	May Discharge C.F.S.	June Area Sq Mi.	June Discharge C.F.S.
Maumee	Sherwood	U.S.G.S. W.S. #129	1903											2190	1313
"	"	"	1904					2190	10400	2190	6645	2190	1130	2190	860
"	"	" #170	1905					2190	3796	2190	2471	2190	4582	2190	2709
"	"	" #206	1906	2190	2130	2190	1030	2190	2400	2190	2980	2190	527	2190	930
				20523	21152	20529	18971	24903	52844	24903	29977	24903	12314	27095	13912
					1.03		.926		2.12		1.20		.495		.514

River	Location	Authority	Year	July Area Sq Mi.	July Discharge C.F.S.	August Area Sq Mi.	August Discharge C.F.S.	September Area Sq Mi.	September Discharge C.F.S.	October Area Sq Mi.	October Discharge C.F.S.	November Area Sq Mi.	November Discharge C.F.S.	December Area Sq Mi.	December Discharge C.F.S.
Maumee	Waterville	U.S.G.S. Rep. 22	1898											6111	8205
"	"	"	1899	6111	285	6111	1362	6111	259	6111	48	6111	521	6111	2323
"	"	"	1900	6111	2094	6111	563	6111	27	6111	41	6111	2619	6111	1509
"	"	U.S.G.S. W.S. #125	1901	6111	2503	6111	47	6111	42	6111	246	6111	98	6111	2585
"	Sherwood	" #129	1903	2190	287	2190	255	2190	689	2190	287	2190	261		
"	"	"	1904	2190	1354	2190	313	2190	232	2190	229	2190	113		
"	"	" #170	1905	2190	534	2190	280	2190	508	2190	307	2190	596	2190	1727
"	"	" #206	1906	2190	787										
				27083	7844	24903	2820	24903	1757	24903	1158	24903	4208	26634	16947
					.289		.113		.0705		.0465		.169		.614

Williams Ex. 34

Chicago Sanitary District

Runoff from Lake Erie Drainage

Table LIXe
Sheet 6

Lake Erie Drainage

River	Location	Authority	Year	January				February				March				April				May				June			
				Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Senaca	Mexico	U.S.G.S.	1898	776	1516	776	636	776	1871	776	600	776	657	776	776												
Riv.	"	Rec. 22	1899	776	656	776	889	776	1407	776	686	776	88	776	776												
	"	"	1900	776	2172	776	1525	776	3279	776	1286	776	715	776	1552												
				1552		1552		1552		1552		1552		1552													
					1.40		.904		2.11		.827		.461		.458												
				July		August		September		October		November		December													
River	Location	Authority	Year	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Senaca	Mexico	U.S.G.S.	1898	776	32	776	44	776	3	776	9	776	24	776	727												
Riv.	"	Rec. 22	1899	776	32	776	44	776	3	776	9	776	24	776	171												
	"	"	1900	776	79	776	743	776	38	776	70	776	24	776	1552												
				1552	111	1552	287	1552	41	1552	79	1552	776	1552	898												
					.0715		.185		.026		.0508		.0155		.578												
				January		February		March		April		May		June													
River	Location	Authority	Year	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Thames	London	U.S.G.S.	1894					1225	709					1225	626	1225	730										
	"	Rec. 22	1895											1225	422	1225	531										
	"	"	1896									1225	817	1225	1119	1225	871										
	"	"	1897					1225	709	1225	817	1225	2267	1225	3484	1225	2132										
									.642		.666		.846		.534												

Williams Ex. 34 — Chicago Sanitary District — Table L1 Sheet

Runoff from Lake Erie Drainage

Lake Erie Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.
Thames	London	U.S.G.S. W.S.P.#4	1895	1228	486					1228	453				
"	"	"	1896	1228	418	1228	545			1228	662				
"	"	"	1897	1228	486										
				3684	1390	1228	545			2456	1115				
					377		444				454				

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.
Tiffin	Defiance	U.S.G.S. W.S.#27	1903											748	740
"	"	" #129	1904					748	3730	748	1865	748	328	748	209
"	"	" #170	1905					748	1287	748	807	748	1494	748	917
								1496	5017	1496	2672	1496	1782	2244	1866
									3.36		1.79		1.19		.831

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.	Area Sq.M.	Disch. in cfs C.F.S.
Tiffin	Defiance	U.S.G.S. W.S.#27	1903	748	311	748	238	748	607	748	159	748	141	748	464
"	"	" #129	1904	748	270	748	109	748	491	748	69.6	748	367		
"	"	" #170	1905	748	250	748	378	748	62	748	76.6	748	197	748	407
				2244	831	2244	454.8	2244	78.7	2244	304.2	2244	974.7	1496	871

Williams Ex. 34.

Table LIX f
Sheet 1
(11 Sheets)

Chicago Sanitary District
Runoff from Lake Ontario Drainage

Summary
Lake Ontario Drainage

Drainage	River	Year	January		February		March		April		May		June	
			Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.
Lake Ontario	Black	1897-1909	18809	30669	18809	30669	18809	30669	18809	30669	18809	30669	18809	30669
"	Genesee	1892-1909	23340	34399	23340	34399	23340	34399	23340	34399	23340	34399	23340	34399
"	Moose	(See Black)												
"	Oneida	1903-1909	9336	15317	9336	15317	9336	15317	9336	15317	9336	15317	9336	15317
"	Oswego	1897-1905	24930	38273	24930	38273	24930	38273	24930	38273	24930	38273	24930	38273
"	Salmon	1901-1905	348	2300	259	640	259	640	259	640	259	640	259	640
"	Seneca	1903-1905	8603	22316	8603	22316	8603	22316	8603	22316	8603	22316	8603	22316
		Totals	96052	145208	96123	145355	96143	145355	96143	145355	96143	145355	96143	145355
		c.f.s. per Sq. Mi.		1.480		1.446		2.435		3.161		2.005		1.254
Drainage	River	Year	July		August		September		October		November		December	
			Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.	Area Sq. Mi.	Discharge c.f.s.
Lake Ontario	Black	1897-1909	18744	17476	18744	11673	18744	22306	18744	20693	18744	34709	18744	48119
"	Genesee	1892-1909	23333	8706	23333	10042	23333	23538	23333	7686	23333	26550	23333	47263
"	Moose	(See Black)												
"	Oneida	1903-1909	6810	6854	6810	6452	6810	6810	6810	3088	6810	6810	6810	9657
"	Oswego	1897-1905	24930	16178	24930	29315	24930	39910	24930	45238	24930	39910	24930	38854
"	Salmon	1901-1905	259	2363	259	2407	259	2402	259	2775	259	2402	259	2402
"	Seneca	1903-1905	8603	13027	8603	12277	8603	12603	8603	10684	8603	13777	8603	12403
		Totals	82161	76348	82161	74166	82161	110556	82161	71160	82161	127446	82161	176469
		c.f.s. per Sq. Mi.		0.881		0.795		0.446		0.912		1.116		1.201

Williams Ex. 34. *Table LIX f*
Sheet 2

Chicago Sanitary District

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

*** 3 days

River	Location	Autocl	Nor-	January		February		March		April		May		June	
				Area Sq Mi	Disch. Cu Ft per Sec	Area Sq Mi	Disch. Cu Ft per Sec	Area Sq Mi	Disch. Cu Ft per Sec	Area Sq Mi	Disch. Cu Ft per Sec	Area Sq Mi	Disch. Cu Ft per Sec	Area Sq Mi	Disch. Cu Ft per Sec
Black	Hammond Whiting	N.S.Y.D.	1917			609	2160	609	6317	609	9494	609	9494	609	273
"	"	N.S.Y.D.	1918	609	3402	609	3906	609	3901	609	4654	609	4654	609	1018
"	"	N.S.Y.D.	1919	609	1712	609	2336	609	3031	609	13194	609	13194	609	218
"	"	N.S.Y.D.	1920	609	2334	609	4704	609	2670	609	13576	609	3711	609	1632
"	"	N.S.Y.D.	1921	609	2044	609	2401	609	6014	609	4004	609	2387	609	396
(Head Calumet)	Thornton Riverdale	N.S.Y.D.	1922	631	2100	631	4743	631	27100	346	1957	346	912	346	721
"	"	N.S.Y.D.	1923	631	2100	631	4743	631	27100			631	1231	631	2208
"	"	N.S.Y.D.	1924	631	1438	631	3007	631	5944	631	10160	631	4323	631	2277
"	"	N.S.Y.D.	1925	631	2279	631	2024	631	3416	631	10110	631	3161	631	3983
"	"	N.S.Y.D.	1926	630	2010	631	3220	631	5330	630	7110	630	2611	630	2170
"	"	N.S.Y.D.	1927							630	6270	630	2430	630	2130
"	"	N.S.Y.D.	1928					630	6280	630	6280	630	6280	630	2268
"	"	N.S.Y.D.	1929	630	3480	630	3300	630	3480	630	6300	630	1980	630	2268
				6309	30668	6309	47677	5758	110196	6309	113360	6309	62744	6309	21719
					1.38		1.51		3.17		5.44		2.00		1.71

* Diverted to Illinois River Canal at Summit via Sanitary & Ship Canal Nov. 1, 1900

Williams Ex. 34.

Table LIXf
Sheet 3

Chicago Sanitary District

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

*1895-3

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
				2274	386	2274	335	2274	384	2274	345	2274	163		1.61
Black	Whitehall	U.S.G.S.	1897	1851	283	1851	220	1851		1851	243	1851	483	1851	1165
"	"	N.S.G.S.	1898	1851	283	1851	175	1851	483	1851	348	1851	398	1851	2110
"	"	N.S.G.S.	1899	1851	415	1851	287	1851	938	1851	1018	1851	438	1851	3501
"	"	N.S.G.S.	1900	1851	736	1851	1134	1851	1418	1851	1478	1851	394	1851	4230
"	"	N.S.G.S.	1901	1851	413	1851	233	1851	548	1851	338	1851	213		
"	Fairhills	N.S.G.S.	1902					1851	783	1851	2418	1851	2488	1851	3088
Mosic (Black)	Newerkirk	N.S.G.S.	1902	346	614	346	486								
"	Fairhills	N.S.G.S.	1903	1851	278	1851	2735	1851	1917	1851	3937	1851	1878	1851	7229
"	"	N.S.G.S.	1904	1851	488	1851	1178	1851	2751	1851	4713	1851	1713	1851	4714
"	"	N.S.G.S.	1905	1851	333	1851	2328	1851	2783	1851	2335	1851	3088	1851	3607
"	"	N.S.G.S.	1906	1850	238	1850	1208	1850	1783	1850	2280	1850	2780	1850	2110
"	"	N.S.G.S.	1907	1850	328	1850	785	1850	1848	1850	3488	1850	1780	1850	3570
"	"	N.S.G.S.	1908	1850	483	1850	1088	1850	748	1850	1100	1850	478	1850	1470
"	"	N.S.G.S.	1909	1850	1168	1850	1030	1850	1783	1850	1810	1850	730	1850	1110

*Directed to Black River Canal at Mooresville August Canal Rec. 1896, p. 466.

Williams Ex. 34

Chicago Sanitary District

Runoff from Lake Ontario Drainage

Table LIX
Sheet 2

Lake Ontario Drainage

* See note bottom Sheet 5

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Genesee	Mt. Morris	Drainage Basin used 1883 Dunlap Waterways	1892	1070	724	1070	1624	1070	1808	1070	2119	1070	1624	1070	1352
"	" "		1893	1070	1810	1070	1325	1070	2144	1070	2387	1070	2413	1070	336
"	Rochester	N.3°24 Correction	1894	2363	2841	2363	2384	2363	6008	2363	3616	2363	6308 75	2363	2800 75
"	"	N.3°24 Correction	1895	2363	1200	2363	700	2363	4033	2363	3083	2363	900 75	2363	533 75
"	"	N.3°24 Correction	1896	2363	1400	2363	2702	2363	3725	2363	7623	2363	1300 75	2363	1000 75
"	Mt. Morris	Drainage Basin used 1883	1898	1070	1810	1070	1900	1070	2552	1070	1582	1070	1160	1070	767
"	Rochester	" F803 Correction	1899	2363	3660	2363	1650	2363	3400	2363	3080	2363	1200 75		
"	Mt. Morris	N.3°10	1903											1070	626
"	Rochester	N.3°206 Correction	1904					2360	18900	2360	7460	2360	3160 75	2360	2230 75
"	Mt. Morris	N.3°10	1904	1070	2764	1070	4983								
"	Rochester	N.3°206 Correction	1905	2360	2800					2360	4150	2360	1460 75	2360	1670 75
"	"	N.3°206 Correction	1906	2360	3250	2360	1320	2360	7680	2360	5110	2360	2130 75	2360	1300 75
"	"	N.3°244 Correction	1907	2360	6330	2360	1500	2360	5400	2360	4210	2360	2810 75	2360	1830 75
"	"	N.3°241 Correction	1908	2360	3790	2360	5940	2360	9080	2360	4000	2360	6020 75	2360	2420 75
"	"	N.3°184 Correction	1909	2360	2700	2360	6000	2360	4200	2360	4350	2360	3850 75	2360	1280 75
				25510	34599	23160	32228	24470	57967	26650	54810	26630	37141	25335	19841
					1.3557		1.3918		2.363		2.044		1.394		.777

Chicago Sanitary District

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Genesee	Mt. Morris	Drainage Water Supply Paper 183	1892	1070	1912	1070	1327	1070	230	1070	306	1070	547	1070	1346
"	"	"	1893	1070	228	1070	325	1070	316	1070	373	1070	518		
"	Rochester	W.S. Paper 184	1893											2365	3914
"	"	W.S. Paper 184 Correction	1894	2365	792 / 73	2365	732 / 73	2365	1300 / 73	2365	920 / 73	2365	1600 / 73	2365	1100
"	"	W.S. Paper 184 Correction	1895	2365	390 / 73	2365	400 / 73	2365	250 / 73	2365	220 / 73	2365	300 / 73	2365	1700
"	"	W.S. Paper 184 Correction	1896	2365	645 / 73	2365	440 / 73	2365	240 / 73	2365	2000 / 73	2365	745 / 73		
"	Mt. Morris	Drainage Water Supply Paper 183	1897											1070	882
"	Rochester	Drainage Water Supply Paper 184 Correction	1898					2365	642 / 73	2365	1180 / 73	2365	2235 / 73	2365	2400
"	Mt. Morris	Drainage Water Supply Paper 183	1898	1070	418	1070	742								
"	"	W.S. Paper 170	1903	1070	470	1070	1208	1070	757	1070	982	1070	1061	1070	1006
"	Rochester	W.S. Paper 206 Correction	1904	2360	1310 / 73	2360	634 / 73	2360	323 / 73	2365	986 / 73	2365	362 / 73	2365	1370
"	"	W.S. Paper 206 Correction	1905	2360	1340 / 73	2360	1230 / 73	2360	680 / 73	2360	583 / 73	2360	1400 / 73	2360	2690
"	"	W.S. Paper 206 Correction	1906	2360	783 / 73	2360	878 / 73	2360	484 / 73	2360	2280 / 73	2360	3650 / 73	2360	4070
"	"	W.S. Paper 244 Correction	1907	2360	1470 / 73	2360	323 / 73	2360	362 / 73	2360	1070 / 73	2360	1340 / 73	2360	4930
"	"	W.S. Paper 244 Correction	1908	2360	1780 / 73	2360	733 / 73	2360	280 / 73	2360	260 / 73	2360	350 / 73	2360	380

* Diverted to Erie Canal at Rochester 122 cfs. Rep. N.Y.S.E. 1890 p. 419
less seepage 47 cfs. Barge Canal Rep. 1901, p. 930. Net correction 73 c.f.s.

Williams Ex. 34

Table LIII
Sheet 2

Chicago Sanitary District.

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Genesee	Rochester	U.S.G.S. W.S. 221 Correction	1909	2360	487 73	2360	325 73	2360	293 73	2360	377 73	2360	439 73	2360	493
				25933	42700	25933	40012	26600	7686	26830	12243	26830	13931	26830	26481
					.497		.393		.268		.457		.329		.389
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Oneida	Euclid	U.S.G.S. W.S. 97 Correction	1903	1400	4186	1400	6179	1400	10619	1400	9143	1400	2035 221	1400	1833 221
"	"	W.S. 189	1904	1313	2162	1313	3403	1313	5934						
"	"	W.S. 170	1905	1313	2499	1313	1592	1313	2977						
"	"	W.S. 236 Correction	1906	1310	4240	1310	3170	1310	3200	1310	5970	1310	3330 221	1310	2390 221
"	"	W.S. 211 Correction	1907	1400	5980	1400	2510	1400	2940	1400	4020	1400	4360 221	1400	1470 221
"	"	W.S. 241 Correction	1908	1400	4130	1400	4620	1400	5610	1400	6630	1400	5310 221	1400	2680 221
"	"	W.S. 281 Correction	1909	1400	2090	1400	3840	1400	6090	1400	7360	1400	6330 221	1400	3660 221
				9336	25247	9336	25644	9336	37370	6910	33143	6910	23310	6910	13108
					2.65		2.70		3.92		4.79		3.37		1.90

* Diversions to Oswego Canal 333 c.f.s. Rep. N.Y.S.E. 1893, p. 120 less seepage 112 c.f.s. Barge Canal Rept. 1901, p. 930. Net correction 221 c.f.s.

Williams Ex. 34

Chicago Sanitary District. Table LIX f Sheet 7

Runoff from Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.
Oswego	Euclid	B.S.D.S. N.S.S.S. Diversion	1903	1400	827 221	1400	1412 221	1400	1230 221	1400	2930 221	1400	2712 221	1400	2207
"	"	N.S.S.S. Diversion	1906	1310	1780 221	1310	1080 221	1310	744 221	1310	962 221	1310	1080 221	1310	2370
"	"	N.S.S.S.	1904											1313	1344
"	"	N.S.S.S. Diversion	1907	1400	1580 221	1400	930 221	1400	914 221	1400	973 221	1400	2190 221	1400	2360
"	"	N.S.S.S. Diversion	1908	1400	1720 221	1400	1288 221	1400	728 221	1400	837 221	1400	1230 221	1400	1030
"	"	N.S.S.S. Diversion	1909	1400	1820 221	1400	672 221	1400	667 221	1400	922 221	1400	1140 221	1400	1210
				2910	8834	2910	6902	2910	5088	2910	7215	2910	9657	2723	10351
					1.25		.931		.737		1.09		1.10		1.26
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.	Area Sq. mi.	Discharge c.f.s.
Chicago	High Dam	U.S.E.D. N.S.S.S. Diversion	1897							3000	1006	3000	1586	3000	3201
"	"	N.S.S.S. Diversion	1898	3000	1896	3000	1238	3000	3818	3000	2578	3000	1963	3000	1311
"	"	N.S.S.S. Diversion	1899	3000	1232	3000	1473	3000	1874	3000	1694	3000	1734	3000	1985
"	"	N.S.S.S. Diversion	1900	3000	3077	3000	1835	3000	1991	3000	1825	3000	1845	3000	3132
"	"	N.S.S.S. Diversion	1901	3000	3376	3000	1874	3000	2710	3000	1857	3000	1938	3000	2632

Williams Ex. 34.

Table LIX(1)

Chicago Sanitary District Sheet 6

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

River	Location	Authority	Year	January Area Sq.Mi.	January Discharge C.F.S.	February Area Sq.Mi.	February Discharge C.F.S.	March Area Sq.Mi.	March Discharge C.F.S.	April Area Sq.Mi.	April Discharge C.F.S.	May Area Sq.Mi.	May Discharge C.F.S.	June Area Sq.Mi.	June Discharge C.F.S.
Oswego	Minetto	U.S.G.S. W.S. 82 Correction	1902	4990	8722	4990	6238	4990	18340	4990	12345	4990	5567 983	4990	6216 983
"	Battle Island	W.S. 129 Correction	1904							4990	19330	4990	13320 983	4990	7497 983
"	" "	W.S. 170 Correction	1905							4990	16370	4990	7978 983	4990	6748 983
				24990	26273	24990	21478	24990	45573	39970	104331	39970	73461	39970	49743
					1.05		.860		1.82		2.61		1.84		1.24

River	Location	Authority	Year	July Area Sq.Mi.	July Discharge C.F.S.	August Area Sq.Mi.	August Discharge C.F.S.	September Area Sq.Mi.	September Discharge C.F.S.	October Area Sq.Mi.	October Discharge C.F.S.	November Area Sq.Mi.	November Discharge C.F.S.	December Area Sq.Mi.	December Discharge C.F.S.
Oswego	High Dam	U.S.G.S. W.S. 49 Correction	1897	3000	2174 983	3000	2370 983	3000	1248 983	3000	1076 983	3000	1821 983	3000	4168
"	" "	W.S. 65 Correction	1898	3000	1834 983	3000	925 983	3000	1377 983	3000	2018 983	3000	4152 983	3000	3899
"	" "	W.S. 65 Correction	1899	3000	748 983	3000	612 983	3000	615 983	3000	585 983	3000	1095 983	3000	1612
"	" "	W.S. 65 Correction	1900	3000	966 983	3000	669 983	3000	670 983	3000	853 983	3000	2418 983	3000	9077
"	" "	W.S. 65 Correction	1901	3000	3740 983	3000	1978 983	3000	1871 983	3000	2130 983	3000	2901 983	3000	6806
"	Minetto	W.S. 82 Correction	1902	4990	8338 983	4990	6998 983	4990	3057 983	4990	4618 983	4990	5797 983	4990	3116

Williams Ex 34.

Table LIXf
Sheet 9

Chicago Sanitary District.

Runoff from Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Chicago	Drainage Canal	U.S.E.& W.S. Commission	1904	4990	4418	4990	3231	4990	3223	4990	4904	4990	4719		
"	"	U.S.E.& W.S. Commission	1905	4990	7777	4990	4668	4990	5145	4990	4731	4990	6130	4990	8387
				5970	46575	5970	27315	5970	25233	5970	28859	5970	37777	5970	39040
					925		734		630		.720		.944		1.113
				January		February		March		April		May		June	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Salmon	Pulaski	U.S.E.& W.S. W.S.#3	1901							264	2894	264	859	264	1065
"	"	W.S.#7	1903							264	1381	264	232	264	382
"	"	W.S.#9	1904							264	3173	264	2143	264	411
"	"	W.S.#10	1905							264	2927	264	935	264	1043
"	"	W.S.#26	1906	239	1340	239	640	259	880	239	2330	239	943	239	570
"	"	W.S.#44	1907	239	1160					259	1040	239	894	239	836
				318	2500	239	610	259	880	1374	13978	1374	5974	1374	3907
					482		247		3.40		8.88		3.81		2.45
				July		August		September		October		November		December	
River	Location	Authority	Year	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Salmon	Pulaski	U.S.E.& W.S. W.S.#3	1900					264	219	264	343	264	1267	264	641
"	"	W.S.#5	1901	264	281	264	460	264	287	264	943	264	748	264	930

Williams Dr. Jr. Chicago Sanitary District Table LIX Sheet 10

Runoff from Lake Ontario Drainage

Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Salmon	Fulaski	U.S.G.S. W.S.°82	1902	264	394	264	611	264	373	264	615	264	796	264	934
"	"	W.S.°97	1903	264	367	264	570	264	214	264	1120	264	486		
"	"	W.S.°129	1904	264	443	264	430	264	581	264	874	264	317		
"	"	W.S.°170	1905	264	488	264	411	264	374	264	972	264	1048	264	1131
"	"	W.S.°206	1906	259	390	259	125	259	104	259	519	259	606	264	334
"	"	W.S.°244	1908					259	121	259	153	259	507		
				1579	2563	1579	2407	2102	2775	2102	5339	2102	5805	1320	4190
					1.62		1.52		1.32		2.64		2.76		3.18

River	Location	Authority	Year	January		February		March		April		May		June	
				Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.	Area Sq.Mi.	Discharge C.F.S.
Seneca	Baldwinsville	U.S.G.S. W.S.°97 Correction	1903	3103	3427	3103	5311	3103	7546	3103	8051	3103	4194 762	3103	2799 762
"	"	W.S.°129	1904	3103	2594	3103	4490	3103	6986						
"	"	W.S.°170	1905	3103	3467	3103	2793	3103	4165						
"	"	W.S.°206 Correction	1906	3100	3680	3100	2790	3100	3420	3100	5680	3100	3840 762	3100	3490 762
"	"	W.S.°244 Correction	1907	3100	5580	3100	3460	3100	4370	3100	4560	3100	4610 762	3100	3270 762
"	"	W.S.°291 Correction	1908	3100	4170	3100	3970	3100	5950	3100	5140	3100	5470 762	3100	3590 762
				18609	22918	18609	22814	18609	32437	12403	23431	12403	21162	12403	16157
					1.23		1.225		1.74		1.89		1.705		1.303

*Diversion to Oswego Canal 300 c/s Rept. NYS E. 1893, p 120. 1893 seepage from Erie Canal
Lake Ontario Canal Rept. 1901, p 950 Net correction 762 c/s

Williams Ex. 34. Chicago Sanitary District Table LIXf

Runoff from Lake Ontario Drainage Sheet 11

Lake Ontario Drainage

River	Location	Authority	Year	July		August		September		October		November		December	
				Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.	Area Sq. Mi.	Discharge C.F.S.
Seneca	Baldwinsville	U.S.G.S. N.Y. '97 Correction	1903	3103	2094 / 162	3103	1819 / 162	3103	2976 / 162	3103	4108 / 162	3103	4277 / 162	3103	2837
"	"	N.Y. '09	1904											3103	2411
"	"	N.Y. 1906 Correction	1906	3100	3000 / 162	3100	2210 / 162	3100	1930 / 162	3100	2770 / 162	3100	3870 / 162	3100	3960
"	"	N.Y. 1914 Correction	1907	3100	2410 / 162	3100	1530 / 162	3100	1470 / 162	3100	2240 / 162	3100	3340 / 162	3100	3800
"	"	N.Y. 1914 Correction	1908	3100	2480 / 162	3100	1670 / 162	3100	1780 / 162	3100	1860 / 162	3100	1930 / 162	3100	1590
				12403	13022	12403	10277	12403	10684	12403	13777	12403	16115	13506	14678
					1.05		.828		.860		1.11		1.30		946

Williams Ex 34 Toble LX
Sheet 1

Chicago Sanitary District
Summary Rainfall

Month	Year	Inches of Rainfall		
		Huron-Michigan	Erie	Ontai
January	1900	1.32	2.35	3.6
	01	1.73	2.10	2.4
	02	0.90	1.89	2.3
	03	1.93	2.41	3.2
	04	1.75	4.39	2.7
	Mean	1.55	2.64	2.9
February	1900	3.48	5.04	4.3
	01	1.46	2.06	1.3
	02	1.40	1.42	1.5
	03	2.26	3.43	2.8
	04	2.14	3.24	2.3
	Mean	2.15	3.04	2.8
March	1900	1.62	3.19	3.7
	01	3.01	2.84	3.7
	02	2.87	2.30	2.6
	03	2.02	2.68	3.4
	04	3.10	4.13	3.1
	Mean	2.32	3.03	3.3
April	1900	1.37	1.76	1.3
	01	1.30	2.30	2.0
	02	1.34	1.71	2.0
	03	2.41	4.08	3.1
	04	2.10	2.78	3.1
	Mean	1.82	2.53	2.8
May	1900	2.41	1.63	1.6
	01	3.57	3.99	3.3
	02	3.90	3.23	2.5
	03	3.43	1.84	0.7
	04	3.07	3.18	3.4
	Mean	2.98	2.46	2.3
June	1900	2.00	2.30	1.9
	01	1.80	2.17	3.3
	02	4.91	3.60	4.2
	03	3.64	3.87	4.1
	04	2.23	1.81	3.5
	Mean	2.68	3.11	3.5

Williams Ex. 34. Table LX a
Sheet 2

Chicago Sanitary District
Summary Rainfall

Month	Year	Inches of Rainfall		
		Huron-Michigan	Erie	Ontario
July	1900	4.29	4.38	2.91
	01	3.78	3.82	3.33
	02	3.98	3.93	3.63
	03	3.97	3.69	3.81
	04	2.72	3.50	4.47
	Mean	4.01	4.58	3.83
August	1900	3.98	2.30	1.84
	01	2.79	3.07	3.89
	02	1.70	1.43	2.09
	03	4.03	3.52	3.49
	04	2.93	3.43	3.43
	Mean	2.98	3.12	2.90
September	1900	2.80	2.20	2.61
	01	2.32	3.31	3.23
	02	3.38	4.32	3.33
	03	3.03	1.72	1.76
	04	3.02	2.69	4.38
	Mean	3.11	2.80	2.76
October	1900	2.32	2.01	2.90
	01	2.98	0.33	2.09
	02	2.34	2.37	2.84
	03	2.17	2.41	3.53
	04	2.19	1.88	2.92
	Mean	2.42	1.92	2.96
November	1900	3.79	3.88	3.45
	01	1.33	2.27	3.08
	02	2.33	1.33	1.80
	03	1.71	1.46	1.80
	04	0.47	0.28	0.30
	Mean	1.93	1.87	2.48
December	1900	1.01	0.87	2.31
	01	2.42	4.42	4.01
	02	2.32	3.03	3.20
	03	2.01	2.60	2.63
	04	2.12	2.41	2.94
	Mean	2.10	2.67	3.04
Full Year		30.25	33.77	35.76
Apr.-Nov.		21.93	23.39	23.65
June-Nov.		17.13	17.40	18.48

Williams Ex 34

Table LXb
Sheet 1

Chicago Sanitary District.
Precipitation on
Lakes Huron and Michigan

Stations	1900												
	Jan	Feb.	Mar	Apr	May	June	July	Aug	Sept.	Oct	Nov.	Dec.	Annual
Port Huron	1.26	3.06	2.17	1.30	3.85	2.60	3.86	4.12	1.32	1.14	3.71	0.34	28.73
Harbor Beach	0.60	2.37	2.25	1.63	2.11	2.22	1.60	4.36	0.94	2.13	3.99	0.50	25.34
Port Austin	T	3.13	0.30	1.09	1.19	1.67	1.65	4.17	1.15	3.10	3.65	T	21.32
Harrisville	1.24	4.19	2.03	1.36	2.64	0.53	4.34	5.23	2.25	2.90	3.01	1.37	31.11
Alpena	0.77	2.07	0.76	1.14	1.60	2.41	3.33	2.97	3.23	1.62	2.56	0.37	23.03
Mackinaw	0.88	2.33	0.60	3.15	1.64	4.41	8.96	4.77	12.44	2.28	3.78	1.20	46.46
Manistee	1.22	3.65	1.25	1.50	2.27	1.73	•	•	•	1.50	2.52	1.10	•
Ludington	0.97	3.15	0.63	0.00	2.56	1.55	4.53	2.69	1.85	2.61	3.64	1.50	25.70
Grand Haven	2.71	3.73	2.06	1.59	2.96	1.43	3.73	4.36	2.15	2.35	4.69	0.57	32.33
South Haven	1.38	4.70	2.80	1.76	2.07	1.79	7.24	8.31	1.78	2.33	5.75	0.99	40.00
St. Joseph	1.47	5.24	1.52	1.45	3.50	1.25	4.67	7.73	0.00	2.97	3.86	0.01	34.17
Menominee	0.90	0.00	0.60	0.00	1.72	1.75	6.87	4.13	4.86	5.12	1.31	0.79	27.75
Manitowoc	0.88	1.89	0.98	2.70	1.12	2.43	4.99	3.12	3.27	4.84	2.46	1.06	29.34
Milwaukee	1.63	3.05	1.72	1.74	2.57	1.88	4.93	3.76	3.51	2.22	2.23	0.84	30.10
Chicago	1.21	3.52	1.58	1.07	3.59	2.06	4.64	4.24	1.56	1.35	3.30	0.58	28.65
Goderich (Ont.)	1.10	2.50	2.40	1.20	1.94	3.62	3.00	1.10	1.33	2.03	1.70	0.00	21.92
Snow water	1.85	2.90	1.60	0.10							1.29	1.03	8.35
Wiarton (Ont.)	0.60	2.10	0.24	0.83	2.32	1.20	•	2.99	2.10	2.28	5.15	0.61	•
Snow water	2.40	2.30	1.33	0.10							1.13	2.30	9.80
Collingwood (Ont.)	0.00	0.00	0.00	•	1.96	1.41	2.12	1.92	2.65	2.34	3.38		15.78
Snow water	•	•	•	•							1.85		
Parry Sound (Ont.)	0.38	2.67	0.62	0.89	4.78	2.07	2.81	1.11	4.54	2.85	5.09	0.80	28.11
Snow water	4.62	3.84	1.34	0.12							1.98	2.47	14.77
Sum	27.37	62.73	29.34	24.69	43.89	38.03	72.87	71.68	50.43	47.38	77.03	18.25	
Averages													
The Year	1.52	3.48	1.62	1.37	2.41	2.00	4.29	3.98	2.80	2.52	3.79	1.01	30.79
Apr.-Nov.													23.16
June-Nov													1938

Williams Ex. 34 Table LXb Sheet 2

Chicago Sanitary District
Precipitation on
Lakes Huron and Michigan.

Stations	1901												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Port Huron	1.10	1.38	1.37	1.78	2.93	1.26	2.67	0.34	2.13	1.14	1.19	2.85	20.36
Harbor Beach	0.99	0.62	1.75	1.38	2.18	0.63	2.41	1.35	1.33	2.38	0.89	1.15	17.46
Port Austin	0.65	0.60	1.44	1.68	1.30	0.00	3.10	1.18	0.66	1.82	0.68	0.00	13.61
Harrisville	2.01	0.77	4.44	2.93	3.26	1.62	3.50	4.36	3.19	3.44	0.80	1.31	31.71
Alpena	1.20	0.35	3.23	1.51	2.10	1.11	3.95	2.23	3.36	3.08	0.85	1.64	23.23
Mackinaw	1.37	0.30	0.82	1.41	1.71	3.42	6.63	6.16	3.93	4.36	1.47	1.83	33.91
Manistee	2.78	2.00	4.10	0.41	2.21	1.78	4.67	1.60	3.18	3.40	1.73	4.06	32.17
Ludington	1.46	1.05	2.25	0.10	0.76	0.36	1.97	0.25	1.16	1.93	0.79	1.90	14.98
Grand Haven	1.96	1.30	3.71	0.65	1.62	2.16	3.90	0.17	2.98	2.33	1.75	3.07	26.45
South Haven	1.39	0.80	2.37	0.80	2.82	3.06	1.73	1.40	2.02	4.44	1.16	3.01	23.60
St. Joseph	1.01	2.10	3.24	0.20	1.12	1.30	2.40	2.38	2.86	4.72	1.10	3.96	27.05
Menominee	0.85	0.80	3.45	0.35	3.22	2.26	4.64	3.02	2.17	4.47	1.72	0.30	27.85
Manitowoc	1.27	0.73	2.14	0.16	1.80	2.91	4.22	1.42	2.65	2.66	0.67	1.73	25.91
Milwaukee	1.33	1.97	3.62	0.47	1.75	1.12	2.03	1.50	1.86	0.63	0.73	1.69	18.69
Chicago	1.15	2.05	3.38	0.33	2.18	2.47	4.25	2.00	2.92	1.29	0.85	1.70	24.52
Goderich (rain)	0.73		1.80	1.10	2.70	1.60	2.75	1.40	1.33	1.50	1.20	1.50	17.39
Goderich (snow melted)	2.60	2.40	0.80	0.40						0.25	0.30	1.80	8.75
Kincardine (rain)	0.36		1.02	1.79	4.05	2.16	5.09	3.61	3.47	0.37	1.40	1.84	25.16
Kincardine (snow melted)	3.30	2.25	1.89	0.43						0.10	0.30	2.40	10.65
Collingwood (rain)	*	*	*	3.48	3.14	1.39	3.11	2.40	2.89	1.69	*	*	18.10
Collingwood (snow melted)	*	*	*							0.18	*	*	
Parry Sound (rain)	0.47		1.28	1.74	3.33	3.44	7.90	4.08	3.54	4.66	1.87	2.28	34.99
Parry Sound (snow melted)	3.30	4.24	2.23	0.10							1.94	3.76	15.71
Sum	31.33	26.22	54.21	24.26	45.0	34.83	70.89	47.62	47.85	58.96	24.33	40.62	
Averages													
The Year	1.75	1.46	3.01	1.30	2.37	1.80	3.73	2.24	2.57	2.68	1.35	2.42	26.63
Apr.-Nov.													17.99
June-Nov													14.32

Williams Ex. 34. Table LX b
Sheet 3

Chicago Sanitary District
Precipitation on
Lakes Huron and Michigan.

Stations	1902												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Port Huron	0.52	0.76	2.05	1.25	4.53	3.30	5.29	4.05	6.27	2.57	1.73	1.43	33.77
Harbor Beach	0.87	0.33	4.32	1.35	2.91	4.71	7.34	2.48	3.91	3.00	1.60	1.65	34.69
Port Austin	0.20	0.60	1.00	1.00	3.80	4.32	5.60	0.00	2.79	2.18	1.45	1.18	24.72
Harrisville	1.37	0.93	3.43	1.87	2.81	4.11	6.78	1.79	1.81	3.44	1.94	4.09	34.39
Alpena	0.77	0.56	1.51	2.54	2.98	3.14	5.60	2.33	2.44	2.34	2.80	1.75	29.02
Mackinaw	0.39	0.37	1.29	3.58	2.64	4.36	2.21	2.95	1.71	3.32	5.87	2.14	31.43
Manistee	0.90	1.80	4.31	1.93	3.74	5.93	9.01	0.97	0.00	0.55	0.53	1.75	33.22
Ludington	0.23	1.10	2.11	1.70	3.97	6.68	4.93	0.00	0.00	0.30	0.92	1.25	23.79
Grand Haven	0.33	1.48	3.64	1.39	4.30	3.85	4.85	0.53	3.23	3.17	2.76	2.60	34.81
South Haven	0.61	1.25	4.30	2.13	4.19	3.07	3.90	0.65	6.25	1.87	3.92	2.32	36.46
St. Joseph	0.94	1.77	4.24	3.93	5.51	7.38	4.66	1.59	4.37	3.43	3.75	4.03	45.12
Menominee	0.73	1.00	0.46	2.49	2.62	4.99	4.41	1.41	2.38	1.60	2.03	0.85	24.99
Manitowoc	0.26	2.27	2.05	0.91	3.70	3.81	8.89	1.69	2.60	1.81	2.09	2.43	32.97
Milwaukee	0.31	1.13	1.91	0.87	4.66	4.71	4.82	0.53	4.27	1.45	1.83	1.89	28.27
Chicago	2.66	1.33	4.10	2.26	5.08	6.45	3.78	1.44	4.83	2.14	2.03	1.90	38.76
Goderich (Ont.)	0.20	0.06	1.30	1.10	2.70	2.24	2.60	1.03	4.83	2.92	1.45	0.60	21.51
Snow water	2.00	3.30	0.00	0.70							0.45	1.35	7.30
Wiarton (Ont.)	0.11		3.47	2.26	3.81	3.80	3.52	2.70	4.89	4.47	2.32	1.41	34.97
Snow water	1.80	2.30	0.30	0.20							0.20	2.30	7.30
Collingwood (Ont.)	*	*	*	*	3.13	3.73	4.87	3.76	4.03	4.18	1.61	*	*
Snow water	*	*	*	*							0.60	*	*
Parry Sound (Ont.)	0.04	0.34	4.13	2.03	4.86	4.70	5.07	2.70	3.51	3.61	2.64	1.48	37.16
Snow water	2.09	1.39	0.60	0.07							0.28	3.72	8.01
Sum	10.13	18.33	51.64	34.95	74.18	89.34	108.15	32.39	68.27	48.35	44.61	41.70	
Averages													
The Year	0.90	1.40	2.87	1.94	3.90	4.71	5.38	1.70	3.38	2.54	2.35	2.32	33.39
Apr.-Nov.													26.10
June-Nov.													20.26

Williams Ex. 34.

Table LXb
Sheet 4

Chicago Sanitary District
Precipitation on
Lakes Huron and Michigan.

Stations	1903												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Port Huron	1.36	2.46	1.54	2.19	3.68	2.47	4.89	4.26	3.23	2.16	2.78	1.87	32.91
Harbor Beach	1.44	1.31	1.06	1.75	3.33	2.28	2.81	4.52	3.78	2.58	2.27	1.32	28.87
Port Austin	0.87	1.24	0.00	0.81	3.03	2.47	2.67	2.44	3.30	2.03	1.69	1.13	21.67
Harrisville	2.08	2.88	1.86	2.19	2.95	3.32	3.52	5.47	3.63	2.27	1.66	2.22	36.03
Alpena	1.52	2.63	1.51	2.00	2.39	2.57	3.08	3.68	3.02	2.73	1.36	1.07	31.34
Mackinaw	1.60	0.84	4.26	1.56	2.75	2.51	3.73	7.40	4.70	4.22	1.80	3.57	40.96
Manistee	1.80	1.30	3.00	*	*	*	*	0.08	0.90	0.23	*	3.45	*
Ludington	2.60	2.40	0.00	2.61	0.84	2.36	1.30	0.00	0.27	0.33	0.00	3.16	15.87
Grand Haven	1.66	2.31	1.64	4.52	3.06	2.40	2.05	3.83	3.49	1.04	1.24	1.37	33.16
South Haven	2.37	2.23	2.97	3.80	2.39	1.73	3.28	4.74	2.39	1.26	1.18	4.14	34.70
St. Joseph	2.41	2.10	2.01	3.85	1.43	3.70	4.45	3.50	2.05	0.83	1.10	3.00	32.47
Menominee	0.25	0.00	3.23	1.67	4.07	4.76	1.34	3.92	4.68	1.39	1.42	0.97	27.30
Manitowoc	0.70	1.10	2.18	4.01	2.73	0.92	7.92	4.24	2.39	3.41	1.12	0.44	32.16
Milwaukee	0.60	2.01	3.20	2.68	3.03	1.51	4.53	3.56	3.07	2.13	1.49	1.65	33.41
Chicago	1.09	3.03	1.67	3.77	0.93	1.62	4.78	3.49	4.00	1.09	0.34	2.25	28.09
Goderich (Snow water)	0.90 1.55	2.10 2.90	0.80 0.10	1.40 0.95	1.37	3.60	2.40	4.37	3.72	2.82	1.20 1.35	0.80 4.50	25.48 17.25
Wiarton (Snow water)	0.74 3.95	1.34 2.25	2.03 0.10	0.91 T	2.34	3.08	3.24	3.61	5.07	2.26	1.09 0.92	0.53 3.03	26.85 12.27
Collingwood (Snow water)	0.00 *	0.00 *	0.00 *	0.81 0.05	1.99	3.38	3.30	3.85	6.13	3.36	0.00 4.80	0.00 *	23.42 *
Parry Sound (Snow water)	1.14 2.33	1.66 2.21	2.38 0.85	1.88	2.79	2.57	2.89	3.56	4.35	4.89 0.70	0.91 1.18	T 2.99	28.32 9.24
Sum	33.38	48.7	36.6	41.31	45.9	47.47	70.35	76.52	68.82	41.13	30.2	46.95	
Averages													
The Year	1.83	2.86	2.02	2.41	2.55	2.64	3.91	4.03	3.63	2.17	1.71	2.61	31.79
Apr.-Nov													23.05
June-Nov													18.09

Williams Ex. 34. Table LX6
Sheet 5

Chicago Sanitary District
Precipitation on
Lakes Huron and Michigan

Stations	1904												
	Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Port Huron	1.76	1.43	2.62	2.23	1.82	3.12	2.34	3.56	2.72	1.89	0.43	1.33	24.97
Harbor Beach	0.80	1.20	1.05	1.40	2.17	1.26	3.66	1.37	1.90	2.48	0.09	1.27	18.^3
Port Austin	2.25	3.00	2.30	0.90	3.70	*	*	*	*	*	*	*	*
Harrisville	2.13	3.82	2.50	2.54	4.43	3.68	2.61	1.73	1.78	1.57	0.52	2.38	31.71
Alpena	0.97	1.99	2.65	2.64	3.77	3.45	1.04	1.30	1.99	1.63	0.89	1.74	24.68
Mackinaw	0.80	1.35	2.90	2.40	3.63	0.00	2.10	4.30	6.10	3.30	0.45	2.80	35.75
Manistee	1.45	4.70	1.30	*	*	*	2.30	*	*	*	0.40	*	*
Ludington	*	*	*	*	*	1.05	*	*	1.16	2.09	T	*	*
Grand Haven	0.78	0.80	2.18	1.94	4.20	1.24	2.40	2.68	3.29	3.28	T	0.00	22.77
South Haven	2.42	1.43	7.32	1.90	1.05	0.76	3.71	5.18	2.79	2.17	0.22	1.99	30.99
St. Joseph	3.30	1.20	2.40	1.13	*	1.00	*	*	3.90	1.25	0.02	*	*
Menominee	0.35	1.81	2.09	1.63	6.28	1.67	2.43	2.57	4.46	2.15	0.20	0.75	26.18
Manitowoc	0.85	1.89	3.66	2.01	3.21	2.63	2.52	2.22	3.19	3.63	0.09	2.40	30.29
Milwaukee	1.30	1.39	3.46	1.79	2.38	3.65	1.89	3.96	2.64	2.56	0.11	2.67	29.86
Chicago	2.25	1.71	4.57	3.01	1.34	0.33	2.78	4.00	2.63	1.38	0.31	1.21	26.14
Goderich (Imp. Stand. Meter)	0.30 / 2.53	1.00 / 2.10	2.80 / 1.20	2.10 / 0.90	1.70	2.36	2.57	2.10	2.13	1.42 / 0.10	0.80 / 0.83	0.30 / 2.80	19.88 / 11.36
Wiarton (Imp. Stand. Meter)	0.00 / 1.38	0.28 / 2.63	1.64 / 0.63	2.29 / 0.17	2.71	2.67	2.25	1.01	3.13	2.00 / T	0.74 / 0.30	0.63 / 2.38	20.14 / 8.15
Collingwood (Imp. Stand. Meter)	0.00 / *	0.00 / *	0.00 / *	1.34 / *	3.61	3.84	4.88	3.63	3.22	2.74 / *	0.00 / *	0.00 / *	23.46 / *
Parry Sound (Imp. Stand. Meter)	0.00 / 3.30	R / 2.30	1.99 / 1.60	2.17 / 0.93	3.43 / T	3.30	3.82	3.45	4.84	1.34 / T	0.99 / 0.40	1.00 / 2.80	27.27 / 11.36
Sum	22.00	36.79	52.77	33.68	58.61	38.24	43.50	44.28	51.41	37.39	8.01	23.64	
Averages													
The Year	1.73	2.16	3.10	2.10	3.07	2.25	2.72	2.93	3.02	2.19	0.47	2.12	28.98
Apr.-Nov.													19.37
June-Nov.													13.60

Williams Ex. 34 Table LXC
Sheet 1

Chicago Sanitary District
Precipitation on
Lake Erie.

Stations	1900												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Toledo	0.73	4.42	1.57	2.73	2.45	3.41	3.43	2.25	0.82	2.29	2.67	0.78	29.58
Cleveland	2.23	3.61	2.06	1.32	1.26	1.53	4.85	1.79	1.94	1.16	3.01	0.81	25.57
Buffalo	3.82	3.21	3.80	1.13	1.22	1.22	2.97	2.69	3.90	3.39	3.32	1.26	33.93
Brt Down (Snow Meter.)	1.60 1.97	1.33 3.89	0.81 3.96	1.62 0.26	1.21	2.47	3.84	2.30	2.54	1.47	2.90 1.63	0.53 0.46	23.39 12.17
Brt Dunwell (Snow meter)	0.88 0.30	2.81 3.30	0.96 2.80	1.33 0.18	1.99	2.91	4.87	2.27	1.80	1.80	3.68 0.39	0.25 0.23	25.70 7.21
Sum	11.73	23.19	13.30	8.80	8.16	11.49	21.91	11.20	11.00	10.00	19.41	4.34	159.35
Averages													
The Year	2.35	3.04	3.19	1.76	1.63	2.30	4.38	2.30	2.20	2.01	3.85	0.87	31.91
Apr.-Nov.													20.46
June-Nov.													17.07

Stations	1901												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Toledo	1.30	1.13	1.94	2.97	2.85	3.32	2.68	3.91	0.87	1.06	1.25	3.53	26.79
Cleveland	1.18	1.28	2.93	2.10	2.78	3.55	3.77	0.31	7.38	0.80	2.42	4.21	36.71
Buffalo	3.31	3.20	3.03	3.13	3.28	1.39	3.05	2.07	3.29	1.29	2.87	5.52	39.49
Brt Down (Snow meter)	1.20 1.40	0 2.30	2.47 0.35	0.48 1.25	2.94	1.43	2.50	1.54	2.39	0.49	1.33 0.48	2.63 1.81	19.39 8.87
Brt Dunwell (Snow meter)	1.25 1.11	0 1.89	1.90 1.03	1.81 0.70	1.10	1.14	2.72	1.53	7.40	0.97 0.07	2.05 0.70	2.39 1.83	19.17 7.26
Sum.	10.89	10.32	14.72	11.86	12.95	10.83	14.72	12.36	16.53	4.63	11.11	22.17	159.98
Averages.													
The Year	2.18	2.06	2.84	2.36	2.59	2.17	2.94	3.07	3.31	0.93	2.22	4.42	31.09
Apr.-Nov.													19.59
June-Nov.													14.64

Williams Ex. 34. Table LXI. Sheet 2

Chicago Sanitary District
Precipitation on
Lake Erie

Stations	1902												
	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Toledo	0.72	0.62	2.76	0.86	4.72	6.19	4.01	1.79	6.31	1.98	1.40	2.25	33.31
Cleveland	1.25	0.83	2.34	1.85	3.60	9.77	3.14	1.60	5.36	2.41	2.07	3.67	39.89
Buffalo	4.01	2.33	1.81	2.04	1.85	4.20	4.53	1.72	2.73	3.09	1.03	3.57	32.91
Port Dover, Ont.	0.33	0.66	2.02	1.87	2.38	3.42	8.02	1.28	2.34	2.86	1.13	1.52	28.05
Snow meter	1.42	1.08	0.01	0.26							0.62	1.29	4.74
Port Dunnville, Ont.	0.11	0.34	2.30	1.25	3.69	5.41	6.71	1.25	4.60	1.52	1.20	1.44	30.02
Snow meter	1.38	1.23	0.02	0.40							0.20	1.40	4.83
Sum	9.44	7.11	11.57	8.33	16.24	28.99	22.41	7.14	21.74	11.86	7.65	13.14	173.77
Averages													
The Year	1.89	1.42	2.30	1.71	3.25	5.80	3.68	1.43	4.35	2.37	1.53	3.03	34.76
Apr.-Nov.													20.12
June-Nov.													21.10

Stations	1903												
	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Toledo	1.10	3.37	1.87	3.67	1.43	3.87	5.54	6.63	2.71	2.32	1.01	1.74	35.08
Cleveland	1.88	3.87	2.40	3.85	1.46	3.17	3.23	4.13	2.46	3.48	1.91	1.90	33.44
Buffalo	4.23	7.90	3.32	4.48	1.69	3.95	4.07	3.29	0.81	2.13	1.36	3.70	37.93
Port Dover, Ont.	0.81	2.18	3.37	4.27	1.57	3.79	8.62	4.73	0.38	1.31	1.50	1.34	33.97
Snow meter	1.33	1.61	0.82	0.2							0.0	1.31	4.95
Port Dunnville, Ont.	0.32	2.30	2.80	3.99	2.06	3.30	8.37	3.83	0.93	2.37	1.49	1.37	36.34
Snow meter	1.60	1.00	0.10	0.09							0.63	1.50	4.28
Sum	12.07	17.23	13.38	20.36	8.21	18.34	34.25	26.68	7.29	12.03	7.30	13.01	187.30
Averages													
The Year	2.41	3.45	2.68	4.08	1.64	3.67	6.40	5.34	1.46	2.41	1.46	2.60	37.60
Apr.-Nov.													26.46
June-Nov.													20.74

Williams Ex. 34. Table LXc
Sheet 3

Chicago Sanitary District
Precipitation on
Lake Erie

Stations	1904												
	Jan	Feb.	Mar	Apr.	May	June	July	Aug	Sept	Oct.	Nov.	Dec	Annual
Toledo	3.51	2.53	4.35	1.77	2.69	0.51	2.83	3.20	2.94	1.22	0.04	2.33	27.94
Cleveland	4.69	2.95	4.01	2.76	3.70	1.17	4.63	2.29	3.62	1.24	0.41	2.49	34.56
Buffalo	4.78	4.32	3.51	2.79	3.12	2.83	3.87	3.41	2.11	1.93	0.51	2.65	35.83
Port Dover	1.36	1.10	3.56	2.92	3.11	1.89	3.13	4.51	2.52	2.79	0.04	0.84	27.77
Snow water	3.00	1.57	1.04	0.92							0.14	1.53	8.00
Port Burwell	1.18	2.63	2.82	1.79	3.30	1.65	3.00	3.82	2.78	2.23	0.11	1.30	26.00
Snow water	3.33	1.10	0.23	0.90							0.03	1.08	7.31
Sum	21.93	16.20	20.76	13.80	15.92	8.05	17.45	17.23	13.97	9.41	1.28	12.04	167.55
Averages													
The Year	4.39	3.24	4.15	2.76	3.18	1.61	3.50	3.45	2.69	1.88	0.26	2.41	33.52
Apr - Nov													19.33
June - Nov.													13.39

Williams Ex. 34 Table LXd Sheet 1

Chicago Sanitary District
Precipitation on
Lake Ontario

Stations	1900												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kingston rain	1.57	2.19	0.26	1.01	2.35	2.08	2.21	1.23	4.13	2.87	2.62	0.38	23.10
Snow water	1.93	1.63	2.11	0.13							1.08	0.81	7.73
Rochester	4.31	4.44	3.14	1.68	1.31	2.43	3.98	2.03	1.93	3.16	4.45	2.96	38.12
Watertown	4.59	4.01	3.87	0.61	2.37	1.62	2.34	1.10	3.05	3.09	8.70	2.67	38.00
Oswego	4.03	4.19	3.16	1.54	1.24	1.29	3.30	2.10	2.53	3.26	6.53	3.70	37.17
Toronto rain	0.97	2.14	1.67	1.83	0.95	2.43	2.73	2.75	1.42	2.12	3.02	0.61	22.13
Snow water	1.47	3.07	1.83	T	T						0.87	0.22	7.46
Sum	18.39	21.69	18.54	6.85	8.26	9.85	14.56	9.21	13.06	14.50	27.27	11.35	173.73
Averages													
The Year	3.68	4.34	3.71	1.37	1.65	1.97	2.91	1.84	2.61	2.90	5.45	2.31	34.74
Apr-Nov.													20.70
June-Nov.													17.68

Stations	1901												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kingston rain	0.77	0.0	2.83	3.08	3.73	4.14	3.36	3.21	3.11	1.80	1.62	2.97	30.23
Snow water	1.06	1.09	0.84	0.55						T	0.74	0.84	5.12
Rochester	3.83	3.69	3.75	4.26	3.06	2.46	2.87	2.19	3.08	1.41	2.63	4.17	37.20
Watertown	1.85	2.07	4.71	3.78	3.17	3.75	3.73	4.26	3.80	3.23	4.90	3.43	44.70
Oswego	2.73	1.35	3.66	4.35	3.18	4.23	3.08	4.90	3.13	3.43	3.87	6.08	45.09
Toronto rain	0.78	0.00	1.38	3.69	3.47	2.07	3.37	3.87	3.05	0.56	1.33	2.23	25.20
Snow water	1.69	1.44	1.36	0.88							0.32	1.38	7.07
Sum	12.21	9.84	18.53	20.35	16.91	16.45	16.63	18.43	16.17	10.43	15.11	23.45	194.61
Averages													
The Year	2.44	1.97	3.71	4.07	3.38	3.33	3.33	3.69	3.23	2.09	3.08	4.61	38.93
Apr-Nov.													26.11
June-Nov.													18.78

Williams Ex 34. Table LXd Sheet 2

Chicago Sanitary District
Precipitation on
Lake Ontario

Stations	1902												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kingston rain	0.44	0.28	2.47	3.30	1.96	4.17	4.52	2.09	1.34	3.46	1.34	1.22	26.54
Snow water	1.10	0.81	0.12	0.01						T	0.19	1.55	3.90
Rochester	2.5	2.31	1.48	2.48	1.67	4.08	4.43	1.90	1.99	2.22	1.01	3.46	29.73
Watertown	2.41	2.70	3.93	2.81	3.05	5.84	3.48	1.91	2.40	4.00	1.90	2.81	37.24
Oswego	2.49	1.78	3.80	2.21	3.02	4.34	6.48	2.23	2.57	2.24	1.78	4.73	37.87
Toronto rain	0.06	0.92	2.17	2.15	1.89	3.57	4.35	2.38	3.35	2.78	0.98	1.91	26.11
Snow water	2.34	0.58	0.35	0.02						T	0.72	0.71	4.920
Sum	11.60	9.64	14.32	12.98	11.59	22.20	23.26	10.76	11.65	14.70	7.92	15.99	166.31
Averages													
The Year	2.32	1.93	2.86	2.60	2.32	4.44	4.65	2.09	2.33	2.94	1.58	3.20	33.26
Apr. - Nov.													22.93
June - Nov.													18.03

Stations	1903												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kingston rain	0.87	1.05	2.43	3.11	0.32	6.16	4.01	3.8	1.11	3.08	1.10	1.08	28.37
Snow water	1.78	1.45	0.33	0.11						0.14	0.31	1.94	6.06
Rochester	2.54	2.62	3.88	2.81	0.53	3.66	2.55	3.45	1.11	2.93	1.58	1.83	29.44
Watertown	3.01	3.15	3.82	2.70	0.49	4.78	5.52	3.15	1.44	3.94	2.37	2.54	40.91
Oswego	3.49	3.08	4.82	3.25	0.32	5.57	2.61	3.08	2.21	4.88	2.46	3.88	39.65
Toronto rain	0.66	1.50	1.81	3.44	1.79	3.33	4.34	3.65	0.41	2.66	1.00	1.04	25.83
Snow water	2.04	1.30	0.02	0.30	0.01					0.12	0.26	0.33	3.00
Sum	16.39	14.13	17.11	13.77	3.68	23.5	19.03	17.31	6.28	13.75	9.00	13.26	175.06
Averages													
The Year	3.28	2.83	3.47	3.14	0.73	4.70	3.81	3.44	1.26	3.95	1.80	2.65	35.01
Apr. - Nov.													22.83
June - Nov.													18.96

Williams Ex 34. Table LXd
Sheet 3

Chicago Sanitary District
Precipitation on
Lake Ontario

Stations	1904												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Kingston rain	0.08	1.30	2.70	3.90	1.92	3.89	3.31	4.07	4.26	2.43	0.33	0.97	28.41
Snow melter	2.07	1.29	0.60	0.32						0.83	0.46	1.43	6.20
Rochester	3.39	2.65	2.93	3.30	3.86	2.71	4.70	2.56	3.95	2.02	0.33	2.46	34.56
Watertown	2.41	3.27	3.08	2.53	5.17	3.53	3.75	3.16	6.48	3.96	0.82	2.32	40.48
Oswego	3.68	3.11	3.69	2.81	2.98	3.72	3.75	2.92	3.24	3.69	0.45	4.12	39.51
Toronto rain	0.32	1.09	2.32	2.64	3.79	2.77	5.13	4.53	3.99	2.42	0.88	0.74	30.04
Snow melter	1.87	1.91	0.60	0.47						0.06	0.03	0.71	3.63
Sum	13.92	14.63	15.87	15.71	17.72	16.62	22.34	17.26	23.92	14.61	2.50	17.20	184.23
Averages													
The Year	2.78	2.92	3.17	3.13	3.44	3.32	4.47	3.43	4.38	2.92	0.50	2.44	36.94
Apr-Nov.													25.63
June-Nov.													19.04

Williams Ex. 34. Chicago Sanitary District Table LXI a Sheet 1

Summary of Mean Temperatures.

Summary
Mean Temperatures of Air and Water
of the
Great Lakes.

Month	Records	Lake Superior		Lake Michigan				Lake Huron		Lake St. Clair		Lake Erie		Lake Ontario	
				Chicago		Milwaukee				Detroit		Cleveland		Toronto	
		Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
Jan.	Water Works			28.0	32.2	23.2	34.8			26.6		29.3	33.5	24.9	35.2
	U.S. Lake Survey*			31.0	32.8							27.0	32.2		
Feb.	Water Works			26.5	32.1	24.6	33.4			24.7		27.7	32.9	22.2	34.36
	U.S. Lake Survey			27.0	32.5							21.5	32.0		
Mar.	Water Works			41.4	34.6	37.5	35.4			37.2		39.0	34.1	32.8	34.8
	U.S. Lake Survey			34.7	33.8							41.3	36.7		
Apr.	Water Works			46.2	41.1	42.4	39.3			44.6	41.6	46.8	40.2	48.3	38.3
	U.S. Lake Survey	42.9	35.1	45.7	40.6			44.9	40.4	47.8	41.6	46.9	39.2	46.2	40.7
May	Water Works			57.1	48.2	53.1	43.6			56.9	51.8	58.8	51.1	54.4	42.6
	U.S. Lake Survey	45.1	37.5	51.3	45.4			52.3	46.1	58.8	51.2	58.9	50.6	53.6	00.6
Jun.	Water Works			68.4	57.5	65.4	47.9			67.2	65.1	68.3	62.3	65.1	45.8
	U.S. Lake Survey	52.0	41.6	62.8	54.8			65.1	58.7	67.2	62.4	69.5	64.1	64.0	50.5
July	Water Works			74.4	65.1	71.4	50.1			72.5	70.6	74.0	78.0	70.1	45.1
	U.S. Lake Survey	60.2	49.3	69.5	63.1			72.6	67.6	73.4	69.7	74.8	71.9	69.1	64.6
Aug.	Water Works			72.9	68.3	69.7	54.4			70.1	71.1	72.0	71.4	67.7	52.8
	U.S. Lake Survey	65.7	56.7	72.8	67.8			75.5	70.0	74.6	72.6	75.1	72.9	70.9	67.0

*U.S. Lake Survey temperatures are the mean of readings at several stations. See Table LXI c.
Water Works temperatures are the mean from 1907 to 1911.

Williams Ex. 34.

Table LXI e
Sheet 2

Chicago Sanitary District

Summary of Mean Temperatures

Summary
Mean Temperatures of Air and Water
of the
Great Lakes

Month	Records	Lake Superior		Lake Michigan				Lake Huron		Lake St. Clair		Lake Erie		Lake Ontario	
				Chicago		Milwaukee				Detroit		Cleveland		Toronto	
		Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
Sept	Water Works			66.3	69.5	63.0	63.8			64.1	67.0	67.8	67.9	64.2	64.3
	U.S. Lake Survey*	60.3	53.8	66.4	62.1			68.0	66.2	69.6	67.9	69.7	68.8	66.4	65.1
Oct	Water Works			54.6	55.3	50.6	50.5			50.7	53.2	55.1	53.2	48.7	47.4
	U.S. Lake Survey	46.4	48.4	51.7	53.0			53.4	54.1	54.2	54.0	55.5	53.2	54.3	55.8
Nov	Water Works			40.9	42.8	37.3	44.5			38.9	43.3	43.4	47.1	37.8	41.4
	U.S. Lake Survey	35.7	41.3	39.9	43.1			41.4	43.5	42.1	43.8	42.7	43.8	38.5	42.1
Dec	Water Works			29.4	33.9	25.6	37.9			28.1	38.1	33.6	37.6	27.9	37.36
	U.S. Lake Survey	21.6	36.5	29.6	34.8			30.5	37.6	30.8	38.6	31.7	38.7	26.6	38.7

*U.S. Lake Survey temperatures are the mean of readings at several stations.
Water Works temperatures are the mean from 1907 to 1911.

Williams Ex. 34.

Table LX1 b
Sheet 1

Chicago Sanitary District

Temperatures of Air and Water of Lake Michigan at Chicago Water Works Pumping Station

Year	Temperature in Degrees Fahrenheit											
	January		February		March		April		May		June	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	27.8	32.3	26.4	32.0	42.6	34.9	39.8	39.5	51.6	45.6	66.2	53.8
1908	28.6	32.0	26.7	32.0	40.6	34.6	49.0	41.3	58.7	48.5	68.4	57.6
1909	28.8	32.5	32.4	32.2	36.0	33.3	45.1	39.8	55.9	48.2	66.6	56.3
1910	25.7	32.0	24.7	32.0	48.6	35.9	51.2	45.0	53.4	48.0	68.2	57.6
1911	29.2	32.2	32.4	32.5	39.2	34.5	46.1	39.7	66.0	50.6	72.4	62.2
Mean	28.0	32.2	28.5	32.1	41.4	34.6	46.2	41.1	57.1	48.2	68.4	57.5

Year	July		August		September		October		November		December	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	73.3	61.7	71.2	63.7	64.6	61.9	52.6	52.4	41.0	42.2	32.8	34.2
1908	74.3	66.4	73.4	71.8	70.6	65.8	55.2	55.0	43.5	42.1	31.3	33.2
1909	72.3	65.4	74.8	70.6	64.0	64.1	50.6	52.6	48.5	46.4	21.7	34.8
1910	76.0	66.7	73.3	70.2	65.2	64.2	58.4	59.3	36.0	42.3	26.4	32.9
1911	76.0	65.4	71.8	65.0	67.0	66.6	53.3	57.2	35.4	41.0	35.0	34.2
Mean	74.4	65.1	72.9	68.3	66.3	64.8	54.0	55.3	40.9	42.8	29.4	33.9

Williams Ex. 34

Table L X10
Sheet 2

Chicago Sanitary District

Temperatures of Air and Water
of
Lake Michigan at Milwaukee
Water Works Pumping Station

Year	Temperature in Degrees Fahrenheit											
	January		February		March		April		May		June	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	22.4	34.9	23.6	33.2	38.6	34.2	37.2	37.7	48.2	41.6	63.2	45.3
1908	24.5	34.9	23.8	33.3	36.0	35.3	45.2	38.6	54.3	43.1	64.4	46.3
1909	24.4	35.5	27.4	32.4	33.0	35.0	40.5	38.5	52.5	44.2	63.2	48.5
1910	21.1	34.0	19.3	34.0	44.2	36.6	46.9	43.1	50.6	44.7	66.8	48.6
1911	23.8	34.6	28.7	34.0	35.8	35.7	42.4	38.5	59.9	44.5	69.4	51.0
Mean	23.24	34.78	24.36	33.38	37.52	33.36	42.44	39.28	53.10	43.62	65.40	47.94

Year	July		August		September		October		November		December	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	70.1	45.7	67.0	45.4	61.0	48.6	48.8	45.9	37.6	43.1	28.2	38.8
1908	70.8	48.0	70.2	60.3	67.8	48.4	51.6	44.0	39.3	43.9	26.1	38.0
1909	70.2	50.7	71.9	54.4	61.6	55.3	47.6	52.0	44.9	45.9	18.8	37.6
1910	73.5	56.4	70.6	56.1	61.4	57.1	54.8	53.8	32.6	45.2	23.0	32.2
1911	72.6	47.8	68.6	55.6	63.4	59.7	50.3	56.9	37.2	44.4	32.4	38.1
Mean	71.44	50.72	69.66	54.36	63.04	53.82	50.62	50.52	37.52	44.50	25.86	37.94

Williams Ex. 34.

Table LXIb
Sheet 3

Chicago Sanitary District

Temperatures of Air and Water
of
Lake St. Clair at Detroit
Water Works Pumping Station

Year	Temperature in Degrees Fahrenheit											
	January		February		March		April		May		June	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	26.0		21.2		39.2		39.1		51.1		64.8	
1908	25.9		21.8		36.1		43.9		59.2	51.6	68.2	63.9
1909	28.6		29.7		32.9		43.9	39.3	53.7	50.7	67.1	63.5
1910	23.0		22.4		44.0		48.0	44.0	53.8	53.0	66.3	64.0
1911	27.4		28.8		33.6		46.0		64.7		69.4	
Mean	26.38		24.68		37.16		44.38	41.65	56.90	51.77	67.20	63.13

Year	July		August		September		October		November		December	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	71.0	69.5	68.0	69.1	62.8	66.2	47.3	52.4	38.2	42.0	30.5	39.1
1908	72.8	72.3	69.7	72.4	68.6	68.6	53.8	56.2	40.3	43.4	29.8	
1909	71.7	70.0	71.3	71.9	61.4	66.2	47.2	50.9	44.9	44.3	23.0	
1910	73.9		70.6		63.3		54.6		35.7		22.7	
1911	73.6		70.6		64.7		50.8		33.6		33.9	
Mean	72.50	70.60	70.08	71.13	64.06	67.0	50.74	53.17	38.94	43.30	28.08	39.10

Williams Ex 34

Table LXIb
Sheet 2

Chicago Sanitary District

Temperatures of Air and Water of Lake Erie at Cleveland Water Works Pumping Station

Year	Temperature in Degrees Fahrenheit											
	January		February		March		April		May		June	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	23.1	33.8	21.4	32.5	39.5	33.9	40.7	40.3	52.5	48.2	63.5	58.0
1908	26.8	33.8	22.7	33.1	34.8	34.7	44.4	41.3	56.3	49.8	64.6	64.5
1909	34.2	34.4	33.3	33.2	35.5	33.8	47.6	40.2	59.7	50.2	70.2	63.2
1910	26.8	31.9	24.1	31.9	43.3	34.0	49.3	39.4	54.9	51.9	65.5	58.4
1911	33.8	33.7	36.8	34.0	39.8	34.3	51.6	39.8	70.5	53.2	73.5	67.4
Mean	29.3	33.5	27.7	32.9	39.0	34.1	46.8	40.2	58.8	51.1	68.3	62.3

Year	July		August		September		October		November		December	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	71.8	70.4	69.1	70.7	66.0	68.8	50.3	58.3	41.2	46.8	33.1	38.9
1908	67.9	71.2	65.7	71.5	64.2	66.3	52.0	59.0	39.3	47.7	29.9	38.1
1909	76.0	68.9	76.1	72.4	68.9	68.5	56.0	57.6	52.8	49.7	32.5	39.9
1910	74.6	66.2	72.3	70.8	67.3	67.7	58.9	61.9	39.9	48.4	28.3	33.8
1911	73.9	72.2	76.7	71.4	72.8	68.1	58.4	58.0	43.6	46.1	42.3	38.2
Mean	74.0	70.0	72.0	71.4	67.8	67.9	55.1	58.2	43.4	47.1	33.6	37.8

Williams Ex 34. Table LXIb
Sheet 5

Chicago Sanitary District
Temperatures of Air and Water
of
Lake Ontario at Toronto
Water Works Pumping Station

Year	Temperature in Degrees Fahrenheit											
	January		February		March		April		May		June	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	22.1	35.3	18.3	35.1	33.8	34.8	28.4	35.8	48.3	39.1	63.8	41.8
1908	24.4	36.3	19.3	34.4	31.4	34.0	41.8	35.9	56.2	40.7	66.2	41.8
1909	26.4	36.0	26.7	35.0	29.9	34.5	40.9	37.5	53.7	40.6	63.3	44.4
1910	25.5	34.3	21.0	34.2	38.8	37.2	46.9	42.3	52.5	44.2	64.6	47.7
1911	23.9	33.7	23.5	33.1	30.1	33.4	43.3	39.9	61.2	48.5	63.6	53.2
Mean	24.86	33.30	22.20	34.36	32.8	34.78	40.76	38.28	54.38	42.62	64.14	45.78

Year	July		August		September		October		November		December	
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
1907	69.3	41.9	63.3	46.5	61.7	49.7	43.0	42.4	36.9	41.2	29.5	37.7
1908	70.7	44.8	67.0	48.6	63.7	53.7	51.4	48.1	39.6	41.1	29.1	38.2
1909	67.7	43.5	69.1	57.8	60.3	54.1	46.2	43.2	40.6	42.3	29.9	36.8
1910	71.1	49.3	67.8	56.6	59.9	61.6	51.2	52.9	36.0	41.8	21.1	33.3
1911	71.6	43.8	69.2	54.6	60.5	52.2	49.5	50.3	33.9	40.8	33.9	38.8
Mean	70.08	43.06	67.88	52.82	61.22	54.26	48.66	47.38	37.80	41.44	27.90	37.36

Williams E. 34.

Chicago Sanitary District
Temperatures of Air and Water
Lake Michigan
From U.S. Lake Survey Records

Table LXIc
Sheet 1
(6 Sheets)

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Milwaukee Lt. Pier Station												
1904					36.8	34.2	43.8	40.1	52.9	46.4	61.6	53.9
1905					30.6	33.4	40.6	40.7	54.3	47.4	64.4	53.1
1906	31.0	32.8	27.0	32.5								
Mean	31.0	32.8	27.0	32.5	33.7	33.8	42.2	40.4	53.7	46.9	63.0	53.5
Grand Haven Pier Lt. Sta.												
1904							45.4	42.8	56.8	51.1	66.7	57.9
1905					36.6*	33.8*	43.6	43.2	57.9	51.5	67.3	59.0
1906												
Mean					36.6	33.8	47.5	43.3	56.6	51.9	67.0	58.4
Eleven Ft. Shoal Light Vessel												
1905									45.4	41.8	57.2	53.1
1906							44.8	38.0*	47.5	44.3	60.3	56.1
Mean							44.8	38.0	46.4	43.0	59.2	55.2
Lansing Shoal Light Vessel												
1904									47.5	32.6	37.4	50.1
1905									29.6	40.8	64.5	54.3
1906							44.1*	36.8				
Mean							44.1	36.8	48.6	40.2	61.8	52.2
Mean of Lake	31.0	32.8	27.0	32.5	34.7	33.8	45.7	40.4	51.3	45.4	62.0	54.8
	July		August		September		October		November		December	
Milwaukee Lt. Pier Station												
1904	64.4	61.4	72.8	67.0	64.1	56.8	48.7	45.0	40.1*	43.1*	25.8*	34.1
1905	66.0	61.9	70.8	69.5	64.3	58.8	52.4	51.3	40.2	38.6	32.4	34.5
1906									40.9	42.7	30.9	36.6
Mean	66.6	61.6	71.7	67.0	64.2	57.7	50.6	49.2	40.6	41.8	29.5	35.0
Grand Haven Pier Lt. Sta.												
1904									40.1*	42.8*	28.4	33.2
1905	71.4	62.7	74.6	67.4	69.1	63.5	55.7	53.8	42.1	41.8	34.4	34.8
1906	73.6	64.3	74.7	70.5	72.2	64.6	53.5	51.8	43.0	44.2	32.6	33.9
Mean	73.5	63.5	77.2	69.0	70.6	64.0	53.6	53.7	42.6	42.8	32.5	33.7
Eleven Ft. Shoal Light Vessel												
1905	65.6	62.5	68.7	66.9	63.5	62.8	49.7	45.6	37.3	43.8		
1906	68.4	68.9	69.5	69.7	64.2	61.5	50.0	54.5	39.6	44.1		
Mean	67.0	64.7	69.1	68.2	64.0	62.2	49.8	55.0	38.0	44.0		
Lansing Shoal Light Vessel												
1904									37.8	44.7		
1905	68.3	57.5	73.0	64.3	66.0	62.2	51.8	53.3	37.3	44.3		
1906	71.8	65.5	73.5	68.8	68.7	62.7	50.0	51.5	39.4	43.6	21.8	37.3
Mean	71.0	62.5	73.2	66.0	68.8	62.4	50.9	54.1	37.9	44.2	21.8	37.3
Mean of Lake	69.5	63.1	72.8	67.8	68.4	62.1	51.7	53.0	39.9	43.1	29.6	34.8

* Partial Months

Williams Ex. 34

Table LXIa
Sheet 2

Chicago Sanitary District

Temperatures of Air and Water
of
Lake Superior

From U.S. Lake Survey Records

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Devil's Island Light Station 1905							43.8	36.1	47.7	40.1	54.6	47.2
1906							47.9	38.2	48.3	39.4	61.2	44.3
Mean							45.8	36.2	48.0	39.8	57.9	44.8
Passage Isl. Light Station 1905							37.8	33.0	44.0	38.4	50.9	39.7
1906							42.4	35.5	45.2	37.1	51.1	39.8
Mean							39.7	34.2	44.6	38.8	51.0	39.8
Stannard Rock Light Station 1905									42.0	35.8	45.9	38.3
1906							43.8	34.9	43.6	36.3	48.4	38.3
Mean							43.4	34.9	42.8	36.0	47.2	38.3
Mean for Lake							42.9	35.1	45.1	37.5	52.0	41.6
	July		August		September		October		November		December	
Devil's Island Light Station 1905	69.1	56.4	72.6	64.3	62.2	56.4	48.2	50.0	34.9	42.3	23.8	36.7
1906	71.8	60.6	72.9	63.0	59.1	53.0	50.7	51.4	36.2	41.5		
Mean	70.4	58.5	72.8	63.2	60.6	54.7	49.4	50.7	35.6	41.8	23.0	36.7
Passage Isl. Light Station 1905	56.3	44.4	63.2	54.8	56.5	51.6	44.9	47.5	32.0	40.5	22.8*	37.1*
1906	54.9	42.9	62.3	55.9	58.1	52.9	44.5	46.5	33.3	39.4	17.9*	35.6*
Mean	56.6	44.6	63.2	55.3	57.3	52.2	44.7	47.0	33.8	40.0	20.9	36.4
Stannard Rock Light Station 1905	52.2	42.2	60.3	51.4	54.2	50.3	45.6	48.0	37.4	41.9		
1906	53.2	47.6	61.9	54.1	57.7	53.0	44.8	47.1	37.9	42.2		
Mean	52.7	44.9	61.1	52.7	56.0	51.6	45.2	47.6	37.6	42.0		
Mean for Lake	60.2	49.3	65.7	56.7	60.3	53.8	46.4	48.4	35.7	41.3	21.6	36.5

* Partial Months

Williams Ex. 34. Chicago Sanitary District Table LXIc Sheet 3

Temperatures of Air and Water of Lake Huron

From U.S. Lake Survey Records

* Partial Months

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Spectacle Reef Light Station 1905							40.2*	34.6	42.9	37.0	54.5	47.6
1906							40.7	33.7	48.3	38.3	60.7	51.6
Mean							40.6	34.9	43.6	37.6	57.3	49.6
Charity Island Light Station 1905							47.2*	43.2	56.5	54.6	68.1	67.1
1906							46.2	42.6	54.7	54.6	67.9	67.5
Mean							46.9	47.4	55.6	54.6	69.0	67.3
Lake Huron Lt. Vessel No. 61 1904							45.2*	38.6	60.0	45.4	68.6	57.6
1905							48.7	39.8	56.6	46.6	69.2	59.8
1906												
Mean							47.0	39.0	57.8	46.0	68.9	58.3
Mean for Lake							44.9	40.4	52.3	46.1	65.1	58.7
	July		August		September		October		November		December	
Spectacle Reef Light Station 1904	65.6	62.5	70.3	65.0	63.8	62.7	49.1	50.3	36.4	41.3		
1905	71.3	62.3	71.1	66.7	64.5	61.7	49.5	49.7	37.8	42.6		
Mean	68.6	62.0	70.7	65.8	64.0	62.2	49.3	50.0	37.1	42.0		
Charity Island Light Station 1905	73.6	72.4	73.2	72.7	66.7	67.1	52.5	53.3	40.8	41.9		
1906	73.9	73.1	72.2	73.2	70.2	70.0	52.8	53.3	43.7	42.8		
Mean	73.7	72.8	73.7	74.0	68.4	68.5	52.6	54.3	41.8	42.2		
Lake Huron Lt. Vessel No. 61 1904									41.3	44.6	77.5	36.4
1905	74.5	66.1	72.4	67.7	72.3	63.7	52.3	52.9	44.9	44.5	58.0	39.4
1906	78.6	68.5	81.8	72.3	78.2	70.0	57.0	57.5	43.0	43.7	30.9	31.9
Mean	75.6	67.3	80.1	70.1	77.8	68.0	56.2	58.1	43.9	45.4	30.5	37.6
Mean for Lake	72.6	67.4	73.5	70.0	62.4	66.2	53.4	54.1	41.4	43.5	30.5	37.6

Williams Ex. 34. *Table LXLL*
Sheet 2.

Chicago Sanitary District

Temperatures of Air and Water
of
Lake St. Clair
from U. S. Lake Survey Records

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Depot Pt. Lt. House No. 13												
1904							45.8	41.0	53.2	51.5	67.2	62.4
1905							50.7	42.7	52.3	50.9	67.3	62.5
1906												
Mean							47.8	41.6	52.8	51.2	67.2	62.4
	July		August		September		October		November		December	
Depot Pt. Lt. House No. 13												
1904	73.3	69.7	72.7	70.6	68.6	66.1	55.3	56.5	42.8	42.1	27.6	32.5
1905	73.3	70.9	74.4	74.2	70.5	69.7	53.7	53.4	42.2	43.4	31.6	34.8
1906												
Mean	73.4	69.7	74.6	72.4	69.6	67.9	54.2	54.0	42.0	42.8	30.8	34.6

a. Partial Months

Williams Ex. 34

Chicago Sanitary District
Temperatures of Air and Water
Lake Erie
From U.S. Lake Survey Records

Table L X I c
Sheet 5

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Toledo Harbor Light Station												
1904			16.4*	32.0*			47.6*	43.1*	62.0	57.5	73.8	69.2
1905	24.2	32.0					51.4	43.7	60.7	57.0	73.7	68.9
1906												
1907	29.9	32.3	26.6	32.1	41.3	36.7	41.2	39.1	54.9	49.4	67.1	63.3
Mean	27.0	32.2	21.5	32.0	41.3	36.7	46.7	42.2	59.9	54.6	71.5	66.7
S.E. Shoal Light Vessel												
1905											70.9*	70.3*
1906							56.7*	41.6*	61.5	51.2	72.2	63.0
Mean							56.7	41.6	61.5	51.2	71.6	67.6
Horseshoe Reef Light Station												
1904							40.9*	42.6*	54.0	45.0	63.5	60.3
1905							43.4	34.9	54.7	48.9	65.1	59.0
1906											68.1	57.3
1907									59.0	45.7	70.9	65.1
1908												
Mean							42.2	33.4	55.9	45.9	66.9	60.5
Mean for Lake	27.0	32.2	21.5	32.0	41.3	36.7	46.9	39.2	58.4	50.4	69.5	64.1
	July		August		September		October		November		December	
Toledo Harbor Light Station												
1904									40.9*	40.8*	28.9	32.2
1905	77.8	76.4	75.6	73.2	71.8	68.2	57.4	55.8	41.3	40.1	32.1*	33.8
1906	78.2	73.0	80.0	77.2	73.7	72.2	54.9	53.3	44.3	40.3	31.5	33.7
1907	76.5	72.0	74.6	72.1	69.5	67.0	52.7	53.3	42.6	41.7	33.7	34.1
Mean	76.5	73.8	76.7	74.2	71.5	69.5	55.3	54.5	41.9	41.4	31.5	33.4
S.E. Shoal Light Vessel												
1904	77.3	73.5	78.1	77.4	70.2	68.7	57.4	60.1	45.1	42.4	37.5*	34.6
1905	76.7	73.5	80.3	76.2	74.9	72.1	58.5	59.2	47.0	44.8	34.9*	38.2
Mean	77.0	72.9	79.2	76.8	72.6	70.4	58.0	59.2	46.0	45.1	36.2	37.0
Horseshoe Reef Light Station												
1904									37.8*	43.6*	32.8*	34.6
1905	71.6	69.6	71.5	69.8	65.3	66.8	53.6	57.9	39.8	40.7	31.5*	38.1
1906	73.7	69.4	74.7	69.2	68.2	67.3	53.3	55.1	40.2	42.2	34.0*	38.3
1907	70.2	69.1	69.6	69.8	64.5	66.9	51.0	55.9	43.1	43.3	33.7*	36.9
1908	74.1	71.3	73.3	70.9	69.2	68.3	59.3	58.8	44.7	45.4	32.5*	37.7
Mean	72.4	69.9	72.3	71.0	66.8	67.4	54.3	58.2	42.1	45.3	30.1	37.0
Mean for Lake	74.8	71.9	75.1	72.9	69.7	68.8	55.5	57.2	42.7	43.8	31.7	35.7

* Partial Month

Williams Ex. 34

Table LXI c
Sheet 6

Chicago Sanitary District

Temperatures of Air and Water
of
Lake Ontario

From U.S. Lake Survey Records

Station and Year	Temperature in Degrees Fahrenheit											
	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air	Water
	January		February		March		April		May		June	
Charlotte Light Station												
1904							45.0	42.3	52.4	48.5	63.2	59.0
1905							44.6	42.9	53.0	50.3	63.9	59.3
1906												
Mean							45.8	42.6	53.7	49.4	64.6	59.8
Gallop Island Light Station												
1904							46.5	37.6	51.1	45.6	62.1	56.4
1905							48.1	40.2	56.1	49.3	64.7	60.2
1906												
Mean							46.6	38.9	53.6	47.4	63.4	58.3
Mean for Lake							46.2	40.7	53.6	48.4	64.0	58.5
	July		August		September		October		November		December	
Charlotte Light Station												
1904									41.8	40.8	36.3	32.6
1905	70.7	64.5	69.4	64.9	64.8	62.6	55.3	55.3	40.1	40.0	34.4	33.9
1906	60.3	57.2	67.5	67.5	67.9	67.2	54.0	54.0	41.9	42.3	36.7	35.8
Mean	65.5	60.8	68.4	63.2	66.3	64.9	54.6	54.6	41.2	41.7	36.8	33.4
Gallop Island Light Station												
1904									42.8	40.6	30.4	32.4
1905	71.6	66.5	71.0	68.7	66.3	65.4	55.6	56.2	38.6	42.0	29.4	31.6
1906	74.0	70.3	73.6	72.9	66.7	65.4	53.2	54.3	33.6	41.1	17.8	32.0
Mean	72.8	68.4	72.3	70.8	66.5	65.4	53.9	56.2	37.8	42.5	22.4	34.0
Mean for Lake	69.1	64.6	70.9	67.0	66.4	65.1	54.3	55.4	39.5	42.1	26.6	33.7

* Partial Months

Williams Ex. 34. Table LXId
Sheet 1 (3)

Chicago Sanitary District
Surface Water Temperatures
1905

Route	Date	Max.	Min.	Mean
Lake Superior				
300 to Ashland & return	July 31 - Aug. 3	64.3	39.4	51.6
	Aug. 25 - Aug. 27	62.8	50.6	57.4
	Oct. 13 - Oct. 16	53.8	44.7	49.7
300 to Duluth and return	June 24 - June 27	56.0	38.7	42.6
	Aug. 19 - Aug. 23	71.3	53.1	61.1
	Sept. 12 - Sept. 15	61.6	41.2	51.8
300 to Otter Is. & return				
" " Duluth " "	Nov. 27 - Dec. 7	43.2	38.2	40.3
Portage Lake & River	Dec. 2 - Dec. 4	33.5	32.0	33.1
St. Mary's River	June 23 - June 28	64.7	52.8	57.0
	July 31 - Aug. 3	65.0	58.5	62.1
	Aug. 24 - Aug. 28	65.8	62.0	63.8
	Aug. 18 - Sept. 1	73.3	54.5	63.4
	Sept. 11 - Sept. 17	64.9	58.6	61.6
	Oct. 8 - Oct. 18	56.6	50.3	53.4
	Nov. 27 - Dec. 8	41.4	33.4	38.2
Lake Michigan				
Mackinac to Chicago				
To Escanaba to "				
To Mackinac	Aug. 24 - Aug. 31	75.9	64.0	70.3
Mackinac to Green Bay	Sept. 22 - Sept. 24	62.7	58.9	61.3
Traverse Bay to Chicago				
to Mackinac	Oct. 10 - Oct. 13	62.3	42.9	57.1
Mackinac to Milwaukee				
to Mackinac	Nov. 17 - Nov. 27	46.4	38.0	42.6
Grand Haven to Milw-				
aukee to Ludington	Feb. 21 - Feb. 22	37.7	32.3	30.0

Williams Ex. 34.

Table LXI d
Sheet 2

Chicago Sanitary District
Surface Water Temperatures
1905

Route	Date	Max.	Min.	Mean
Lake Huron				
Port Huron to Detour to Port Huron	June 22 - June 29	64.9	49.3	57.2
Port Huron to Detour to Mackinac to Port Huron	Aug. 18 - Sept. 1	74.4	47.1	67.9
Port Huron to Goderich	July 7	69.3	63.9	68.3
Goderich to Harbor Beach	July 11	72.0	67.3	69.97
Harbor Beach to Tawas City	July 14	71.3	60.5	68.94
Tawas City to Bay City	July 16	74.8	65.8	71.26
Bay City to Tawas City	July 19	72.9	66.0	69.47
Tawas City to Kincardine	July 20	68.7	63.3	63.79
Kincardine to Southampton	July 26	64.3	30.1	37.54
Southampton to South Pt.	July 27	62.0	47.2	57.8
Alpena to Presque Isle	July 31	60.7	39.0	60.0
Presque Isle to Cove Isl.	Aug. 2	64.8	37.2	59.2
Cove Isle. to Southampton	Aug. 5	68.0	60.3	63.86
Southampton to Stokes' Bay.	Aug. 7	75.2	72.0	73.87
Stokes' Bay to Alpena	Aug. 10	69.7	60.8	64.62
Alpena to Duck Island	Aug. 12	65.7	39.5	62.71
Duck Isle. to Stokes' Bay	Aug. 13	67.2	61.2	63.64
Stokes' Bay to Providence Bay	Aug. 20	65.2	32.0	62.97
Providence Bay to Presque Isle.	Aug. 23	63.0	33.3	38.00
Presque Island to Cheboygan	Aug. 24	64.0	61.3	62.64

Williams Ex. 34 Table LXIII Sheet 3

Chicago Sanitary District

Surface Water Temperatures

1905

Route	Date	Max.	Min.	Mean
Lake Huron				
Cheboygan to Mackinac Island	Aug. 25	63.0	62.5	63.72
Detour S.E. and then W to Cheboygan	Aug. 30	61.7	53.8	59.02
Detour to Cheboygan	Sept. 4	60.0	53.3	56.97
Mackinac Isle to Detour	Sept. 9	58.2	56.9	57.53
Detour to Mississaqe Straits	Sept. 13	58.3	54.0	56.3
Mississaqe Straits to Rogers Isle and thence to Cheboygan	Sept. 16	58.3	53.0	57.5
Cheboygan to Duck Isle.	Sept. 19	58.5	56.5	57.47
Duck Isle. to South Pt.	Sept. 20	61.1	56.0	58.98
Alpena to Harbor Beach	Sept. 22	64.8	59.2	61.10
Harbor Beach to Bay City	Sept. 23	66.1	62.2	63.89
Bay City to Gravelly Pt.	Sept. 26	64.0	63.3	63.71
Harbor Beach to Port Sanilac thence to Goderich	Oct. 9	58.2	54.0	56.03
Clark Pt. to Goderich	Oct. 10	53.2	51.0	52.33
Goderich to Port Huron	Oct. 11	57.8	54.0	56.33
Port Huron to Detroit	Oct. 12	57.2	53.9	56.39
Port Huron to Detour	July 30 - Aug. 4	67.9	59.5	63.76
	Aug. 24 - Aug. 28	67.3	63.3	65.93
Port Huron to Detour to Port Huron to Mackinac to Port Hu	Sept. 11 - Sept. 25	60.9	51.8	62.48

Williams Ex. 34. Table LXI d Sheet 4

Chicago Sanitary District
Surface Water Temperatures
1903

Route	Date	Max.	Min.	Mean
Lake Huron				
Port Huron to Mackinac to Detour to Port Huron Port Huron to Mackinac to Port Huron. Port Huron to Detour to Port Huron	Oct. 7 - Oct. 19 Nov. 16. - Dec. 10	61.8 45.9	46.7 38.9	50.14 42.28
St. Clair River				
St. Clair River	June 22 - June 29	63	37.6	50.49
	July 30 - Aug. 4	67.2	66.5	66.72
	Sept. 3	69.8	69.7	69.73
	Sept. 18 - Sept. 25	66.3	62.0	64.57
	Oct. 7 - Oct. 19	62	58.6	59.34
	Nov. 16 - Dec. 10	44.9	40.2	43.11
Lake St. Clair.				
Lake St. Clair	June 22 - June 29	71	63.4	67.20
	July 30 - Aug. 4	69.9	68.4	69.13
	Aug. 29	68.4	67.3	67.85
	Sept. 3	69.8	69.4	69.67
	Sept. 10 - Sept. 25	67.4	63.2	65.86
	Oct. 7 - Oct. 19	62.4	57.7	60.0
	Nov. 13 - Dec. 10	42.7	38.9	40.30
Detroit River				
Detroit River	June 20 - June 22	66.3	63.3	66.03
	June 26	68.4	66.0	67.20

Williams Ex 34. Table LXIa Sheet 5

Chicago Sanitary District
Surface Water Temperatures
1903

Route	Date	Max.	Min.	Mean
Detroit River				
Detroit River	July 24	71.2	70.4	70.80
	Aug. 4	69.3	69.3	69.30
	Aug. 15 - Aug. 17	75.4	74.8	75.10
	Aug. 29 - Sept. 1	70.5	69.5	69.97
	Sept. 18 - Sept. 21	66.2	66.1	66.13
	Sept. 28	64.7	64.4	64.53
	Oct. 19 - Oct. 23	57.5	50.4	53.62
	Nov. 13 - Dec. 10	41.5	34.8	39.43
Lake Erie				
Detroit to Erie Erie to Detroit	June 20 - June 21	66.5	61.3	63.3
	June 26 - June 27	70.0	57.0	62.69
Buffalo to Detroit	July 9	67.6	64.5	66.67
	July 24 - July 25	74.3	63.5	70.57
Detroit to Ashtabula to Detroit Detroit to Buffalo. Buffalo to Cleveland Cleveland to Detroit	Aug. 15 - Aug. 17	78.3	74.6	75.33
	Aug. 29 - Sept. 1	72.7	69.5	71.13
	Sept. 18 - Sept. 20	69.3	67.8	68.40
	Sept. 28 - Sept. 29	67.6	63.2	66.83
Detroit to Cleveland to Detroit Detroit to Cleveland to Detroit to Erie to Detroit	Oct. 20 - Oct. 23	53.9	52.6	53.40
	Nov. 13 - Nov. 26	47.5	38.5	43.22

Williams Ex 34. Table. LXII.

Chicago Sanitary District

Meteorological Records at Rochester

Averages of Results Obtained Since Beginning of Experiments in 1891.

Period		Records Made at Mt. Hope Reservoir						
		Depth of evaporation		Mean temperature				Precipitation
Years	Month	Depth in inches from Pan	Depth in inches from Tank	Mean of Maximum	Mean of Minimum	Mean of Month	Mean of Day	Depth in inches
1896-1907	Jan.		0.75		32.6	32.7	24.7	1.867
1896-1907	Feb.		2.79		32.6	32.9	24.9	1.930
1896-1907	Mar.		4.42		34.0	34.0	26.0	2.000
1896-1907	Apr.	4.69	4.67	47.4	34.0	40.7	30.7	2.241
1896-1907	May	6.47	5.54	58.5	43.9	51.2	40.4	2.767
1896-1907	June	6.35	4.54	68.5	53.9	61.2	50.6	3.117
1896-1907	July	6.68	3.44	74.6	61.2	67.9	57.6	3.346
1896-1907	Aug.	5.68	2.84	74.0	60.5	67.3	57.0	3.146
1896-1907	Sept.	4.58	2.03	69.0	55.6	62.3	52.1	3.117
1896-1907	Oct.	2.58	1.33	57.4	45.0	51.2	41.2	2.770
1896-1907	Nov.	1.81	1.34	47.4	34.3	40.9	31.9	2.806
1896-1907	Dec.		1.16		34.3	34.9	28.7	1.966
Totals and Means		44.51	33.13	60.6	51.2	49.5	40.6	27.627

Period		Records of U.S. Weather Bureau					
		Precipitation		Temperature of air in shade		Humidity of air	
Years	Month	Depth in inches from Gauge	Depth in inches from Snow	Mean of Maximum	Mean of Minimum	Mean of Month	Mean of Day
1896-1907	Jan.	2.08	5.13	34.9	24.1	74.7	79.
1896-1907	Feb.	2.20	4.73	36.7	25.0	78.0	79.
1896-1907	Mar.	2.42	3.94	44.7	31.5	80.7	78.
1896-1907	Apr.	2.68	2.84	57.5	41.0	80.7	76.
1896-1907	May	3.08	0.44	68.8	50.0	80.8	74.
1896-1907	June	3.28	0.12	77.2	59.1	80.8	74.
1896-1907	July	3.58	0.00	80.1	63.4	80.8	74.
1896-1907	Aug.	3.38	0.00	78.7	62.1	80.8	74.
1896-1907	Sept.	3.08	0.00	73.1	56.1	80.8	74.
1896-1907	Oct.	2.88	0.00	62.1	45.1	80.8	74.
1896-1907	Nov.	2.68	0.00	50.5	34.7	79.3	77.
1896-1907	Dec.	2.01	2.36	39.6	28.7	79.2	77.
Totals and Means		33.15	34.07	47.8	47.7	73.8	72.

Williams Ex 34 Chicago Sanitary District Table LXIII

Effect of Livingstone Channel

Effect of Livingstone Channel

Year	Huron Elevations				Mich St Clair Flats Elevations				St Clair	Erie Elevations				Mich Erie
	Oct.	Nov	Dec	Mean	Fall	Oct	Nov	Dec	Mean	Fall	Oct.	Nov	Dec	Mean	Fall
1900	580.08	0.66	0.45	580.39	5.65	575.01	574	4.80	574.94	3.38	571.75	1.49	1.45	571.56	9.03
01	.56	.43	.10	.40	.62	4.96	.67	.70	.76	.55	.33	.16	.19	.23	9.17
02	.27	.17	9.93	.12	.04	5.26	.90	5.05	5.08	.04	2.29	2.02	.82	2.04	8.00
03	.53	.41	0.12	.45	.20	.45	.55	.35	.25	.43	.25	1.77	.43	1.82	8.63
04	1.26	.96	.50	.90	.39	.74	.34	.45	.51	.38	.49	2.12	.77	2.13	8.77
05	.22	.93	.67	.94	.58	.60	.32	.17	.36	.31	.31	1.93	.91	.85	8.89
06	0.87	.66	.65	.73	.40	.45	.33	.21	.33	.06	.21	2.17	2.42	.27	8.46
07	1.21	.81	.62	.89	.35	.76	.47	.60	.56	.09	.69	2.81	.26	.85	8.46
Mean				580.63	5.41-6.22%				575.22	3.28-3.78%				571.94	8.69
1908	580.08	0.46	0.23	580.52	5.24	575.64	5.23	4.96	575.28	3.47	572.31	1.71	1.62	571.81	8.71
09	.46	.12		.26	.06	.31	.08		.20	.51	1.76	.51		.69	8.57
10	.66	9.83	9.52	9.81	4.97	.20	4.89	4.44	.84	.28	.88	.46	.34	.56	8.25
11	9.56	.44	.39	.46	.72	4.83	.69	.70	.74	.38	.53	.13	.42	.36	8.10
Mean				580.01	5.00-5.95%				575.01	3.41-4.05%				571.60	8.41
1912	580.04	0.03	0.28	580.45	5.23	575.31	5.23	5.02	575.19	3.32	572.15	1.92	1.55	571.87	8.55
					6.28					3.94					

Changes in Feet

From	to	Huron	St. Clair	Erie	Huron to St. Clair	St. Clair to Erie	Huron to Erie
1900-7	08-11	-0.62	-0.21	-0.36	-0.41	+0.13	-0.28
1908-11	12	+0.41	+0.15	+0.27	+0.23	-0.09	+0.14

Williams Ex. 34. Table LXIV

Chicago Sanitary District

Comparison of Results obtained
With a Haskell Current Meter on Rigid
Support for Regular and Irregular Velocities.

Regular Velocity					Irregular Velocity				Irreg. ratio / Reg. ratio
Group	No. of Observ.	Rev.	Val	Val / Rev.	No. of Observ.	Rev.	Val.	Val / Rev.	
I	69	.536	1.260		137	.533	1.369		
	70	.434	1.075		136	.388	1.027		
	71	.273	.796		133	.221	.663		
	72	.169	.479		134	.115	.330		
	Mean	.363	.928	2.629	Mean	.423	7.082	2.558	.972
II	68	1.019	2.240		128	.956	2.145		
					138				
	Mean	1.019	2.240	2.198	Mean	.989	2.178	2.200	1.000
III	73	1.287	2.574		127	1.368	2.960		
	75	1.297	2.594		135	1.429	3.086		
	81	1.335	2.758						
	90	1.253	2.574						
	Mean	1.293	2.660	2.057	Mean	7.408	3.078	2.143	1.040
II	66	1.761	3.671		140	1.584	3.540		
	84	1.796	3.810						
	88	1.767	3.720						
	89	1.633	3.410						
	Mean	1.733	3.652	2.107	Mean	1.584	3.540	2.235	1.060
I	64	1.964	4.016		135	1.870	4.137		
	65	1.805	3.748		139	2.003	4.292		
	76	1.848	3.741						
	Mean	1.979	4.169	2.106	Mean	1.934	4.212	2.178	1.030
II	78	2.778	5.949		138	2.865	6.135		
	83	2.778	5.737						
	86	2.822	5.934						
	Mean	2.789	5.870	2.141	Mean	2.865	6.135	2.141	1.000

Williams Ex. 34. Table LXV

Chicago Sanitary District
Elevations and Mean Elevations of Lakes for Ten Years Prior and Ten Years Subsequent to Opening of Chicago Drainage Canal

Year	Michigan Elevation	St. Clair Elevation	Erie Elevation
1890	581.11	575.77	573.05
1	0.54	5.09	2.15
2	0.35	4.93	2.18
3	0.37	5.10	2.09
4	0.76	5.22	2.10
5	79.83	4.60	1.17
6	79.93	4.37	1.99
7	80.73	4.39	1.96
8	0.28	5.06	2.19
9	0.29	5.00	7.93
Mean	580.342	575.013	572.012
1900	580.30	574.94	571.94
1	0.37	4.61	1.39
2	0.21	4.82	1.64
3	0.36	5.36	2.39
4	0.82	5.60	2.32
5	0.55	5.33	2.17
6	0.96	5.29	2.26
7	1.03	5.20	2.29
8	- 0.98	5.08	2.69
9	0.21	5.32	2.13
Mean	580.665	575.255	572.210

Gain in Elevation of Subsequent over Prior Decade	580.665 − 580.342 = .323	575.255 − 575.013 = .242	572.210 − 572.012 = .198
	4"	2.8"	2.3"

Williams Ex. 34. *Chart I*

Chicago Sanitary District
Discharge of Lower Detroit River
Gage Relations

Gaging	Mamajuda	Section	Gibraltar	Amherstburg	Ouellette	Width Section	Area	Velocity	Discharge
1. May 8-10, 1909	574.35	573.48	572.65	572.87	(574.17)	1625	27200	2.20	59420
2. June 28-9, 1909	4.72	4.19		3.55	(574.55)	1680	28900	1.80	49880
3. Aug. 29, 1912	4.17	3.69		3.10	573.83	1680	27753	1.40	38868
4. Aug. 30, 1912	4.00	3.43		2.78	573.57	1680	27236	1.48	40498
5. Dec. 5, 1912	3.46	2.84	572.17	2.10	(573.01)	1680	26296	1.58	44300
Average 1-5		3.53		2.88	573.83				46593
" 2,3,4,5		3.54		2.88	573.75				43386
" 3,4,5	573.88	3.32		2.66	573.47				41222

To interpolate Ouellette (1) and (2)
Mean fall Mamajuda to Amherstburg Apr. 24 to May 20
= 574.29-572.99 = 1.30

By statement of Report of C.Y. Dixon p. 11, the fall from Ouellette's to Amherstburg = 1.14
Fall Mamajuda to Ouellette = $\frac{16}{130}$ Mamajuda to Amherstburg

Gaging 1 M = Mamajuda, A = Amherstburg, O = Ouellette
M-A = 574.35-572.87 = 1.48
$1.48 \times \frac{16}{130} = 0.182$ ∴ Ouellette = 574.35-0.18 = 574.17

Gaging 2
M-A = 574.72-573.55 = 1.17
$1.17 \times \frac{16}{130} = 0.14$ ∴ Ouellette = 574.72-0.14 = 574.58

To interpolate Ouellette (5) S = Section
By 3 O-A = 573.83-573.10 = 0.73
S-A = 573.69-573.10 = 0.59
O-A = $\frac{73}{59}$ S-A = 1.237

By 4 O-A = 573.57-572.78 = 0.79
S-A = 573.43-572.78 = 0.65
O-A = $\frac{79}{65}$ S-A = 1.216

Mean (O-A)+(S-A) = 1.226
By 5 S-A = 572.84-572.10 = 0.74
∴ Ouellette's = 0.74 × 1.226 + 572.10 = 573.01

Williams Ex. 34. Chart I

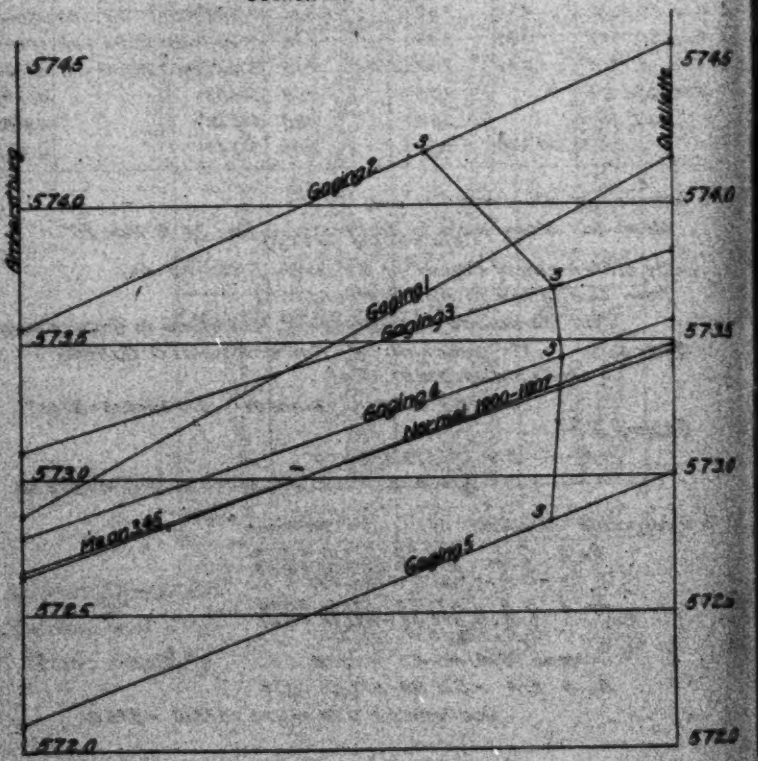
Chicago Sanitary District
Discharge of Lower Detroit River
Gage Relations

Mean St Clair Flats (1900-1907 Open Season) = 575.43
Amherstburg . . . . . = 572.65

$$\frac{\text{Fall St Clair Flats to Ouellette}}{\text{Fall St Clair Flats to Amherstburg}} = 0.703$$

$$\frac{575.43 - \text{Ouellettes}}{575.43 - 572.65} = 0.703$$

Ouellettes = 573.48



Williams Ex 34 *Chart III*

Chicago Sanitary District

Discharge of Lower Detroit River

Trenton Channel

1912

	Monroe	Amherstburg	Fall	Section	w	A	$\frac{A}{w}$	V	Q
Mean 3 days	573.88	572.66	1.22	573.32	1680	26112	15.54	1.579	41,222
Normal Fall	573.60	572.65	0.95	573.16	1680	25843	15.38	1.386	35,818

$$\frac{V_{normal}}{V_{mean}} = \left[\sqrt{\frac{0.95}{1.22}} = 0.882\right]\left[\sqrt{\frac{15.38}{15.54}} = 0.995\right] = 0.878$$

$V_{normal} = .878 \times 1.579 = 1.386$

$Q = 1.386 \times 25,843 = 35,818$ c.f.s.

$M-O = \frac{fl}{150}(M-A)$ or $M-573.48 = \frac{fl}{150}(M-572.65)$ $\therefore M = 573.60$

$M-S = \frac{fl}{150}(M-A)$ or $573.60-S = \frac{fl}{150}(573.60-572.65)$ $\therefore S = 573.16$

Williams Ex 34. Chart II

Chicago Sanitary District

Discharge of Lower Detroit River

Stony Island Channel

1912

	Ouellette	Amherstburg	Fall	Section	w	A	$\frac{A}{w}$	V	Q
Aug 20-21	573.50	572.74	0.84	573.24	1240	7699	6.21	1.500	11549
Normal	573.48	572.65	0.83	573.14	1240	7575	6.11	1.479	11203

$$\frac{V_{normal}}{V_{mean}} = \left[\sqrt{\frac{0.83}{0.84}} = .994\right]\left[\sqrt{\frac{6.11}{6.21}} = 0.992\right] = 0.986$$

$V_{normal} = 0.986 \times 1.500 = 1.479$

$Q = 1.479 \times 7575 = 11203$ c.f.s.

* $S = O - \frac{1}{11}(O-A) = 573.48 - \frac{1}{11} \times 0.83 = 573.48 - 0.34 = 573.14$

Williams E. 34. Chart K

Chicago Sanitary District

Discharge of Lower Detroit River

Livingstone Channel

1912

	Ouellette	Amherstburg	Fall	Section	w	A	$\frac{A}{w}$	V	Q
Dec 17	573.10	572.35	0.75	572.73	500	11883	23.77	2.93	34,838
Normal	573.48	572.65	0.83	573.07	500	12053	24.11	3.103	37,400

$$\frac{V_{normal}}{V_{mean}} = \left[\sqrt{\frac{0.83}{0.75}} = 1.052\right]\left[\sqrt{\frac{24.11}{23.77}} = 1.007\right] = 1.059$$

$V_{normal} = 1.059 \times 2.93 = 3.103$

$Q = 3.103 \times 12053 = 37,400$ c.f.s.

$S = O - \frac{17}{17}(O-A) = 573.48 - \frac{17}{17} \times 0.83 = 573.48 - 0.41 = 573.07$

Williams Ex. 34. *Chart VI*

Chicago Sanitary District

Discharge of Lower Detroit River

Lime Kiln Channel

1912

	Gualette	Anderson	Fall	Section	w	A	$\frac{A}{w}$	V	Q
Dec. 18	572.95	572.17	0.78	572.58	2670	38840	14.55	2.55	99128
Normal	573.48	572.65	0.83	573.09	2670	40282	15.06	2.67	107,339
Oct. 24	573.02	572.06	0.96	572.56	2670	38787	14.51	2.76	106,975
Normal	573.48	572.65	0.83	573.08	2670	40175	15.05	2.61	104,857

Mean for Normal = 106,098

(Dec. 18)

$$\frac{V_{normal}}{V_{mean}} = \left[\sqrt{\frac{0.83}{0.78}} = 1.031\right]\left[\sqrt{\frac{15.06}{14.55}} = 1.017\right] = 1.048$$

$$V_{normal} = 1.048 \times 2.55 = 2.67$$

$$Q = 2.67 \times 40282 = 107,339 \text{ c.f.s.}$$

(Oct. 24)

$$\frac{V_{normal}}{V_{mean}} = \left[\sqrt{\frac{0.83}{0.96}} = .930\right]\left[\sqrt{\frac{15.05}{14.51}} = 1.018\right] = .947$$

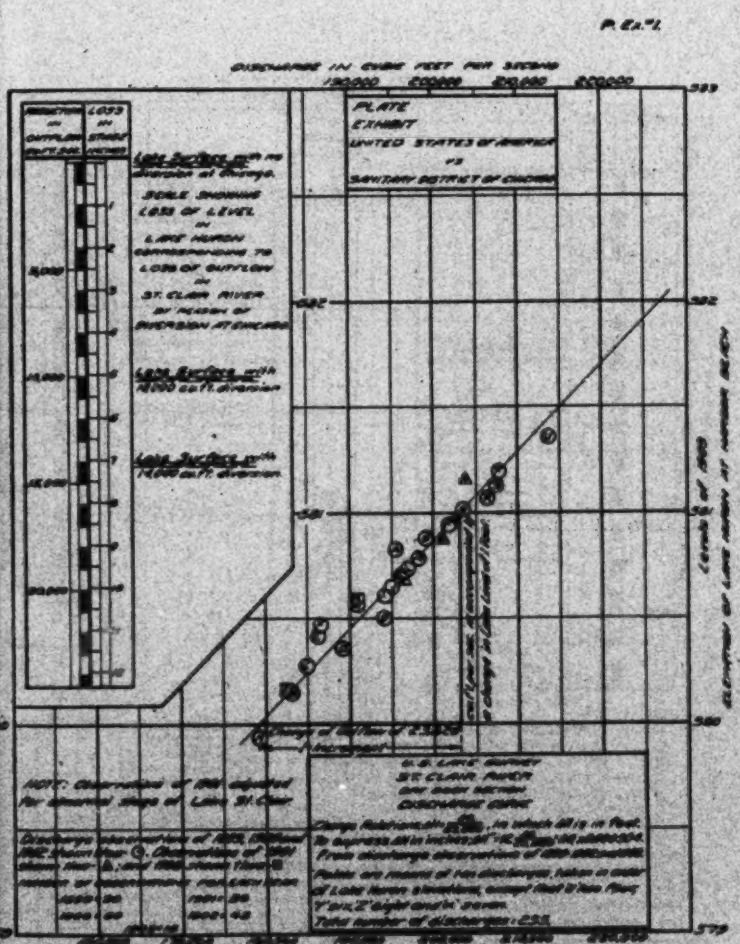
$$V_{normal} = .947 \times 2.76 = 2.610$$

$$Q = 2.610 \times 40875 = 104857 \text{ c.f.s.}$$

Dec. 18 $S = O - \frac{11}{12}(O - A) = 573.48 - \frac{11}{12} \times 0.83 = 573.48 - 0.39 = 573.09$

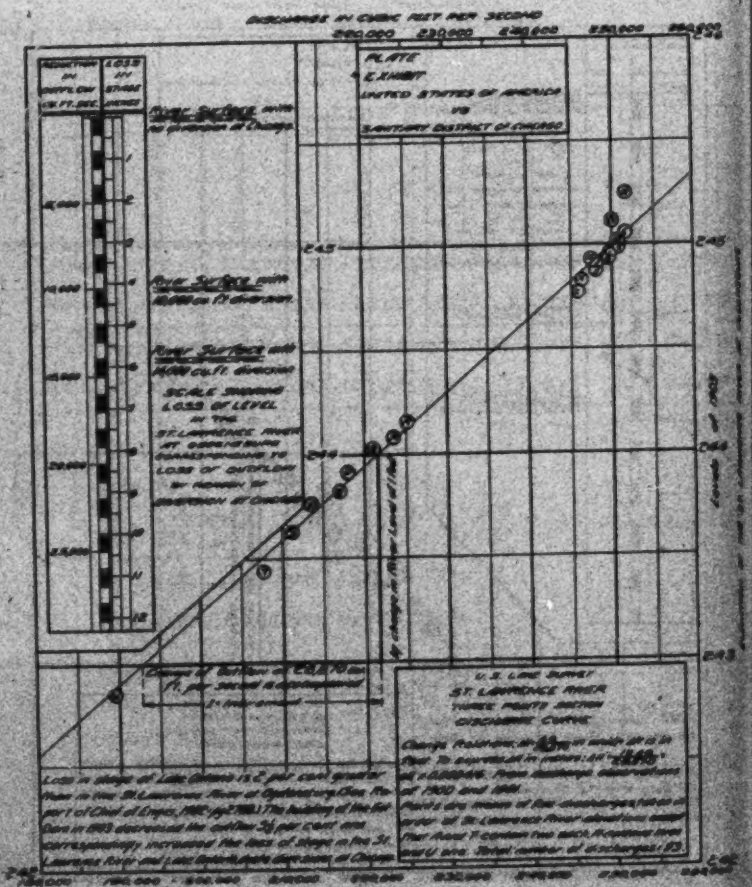
Oct. 24 $S = O - \frac{11}{12}(O - A) = 573.48 - \frac{11}{12} \times 0.83 = 573.48 - 0.40 = 573.08$

Williams Ex. 34. *Plate 1*

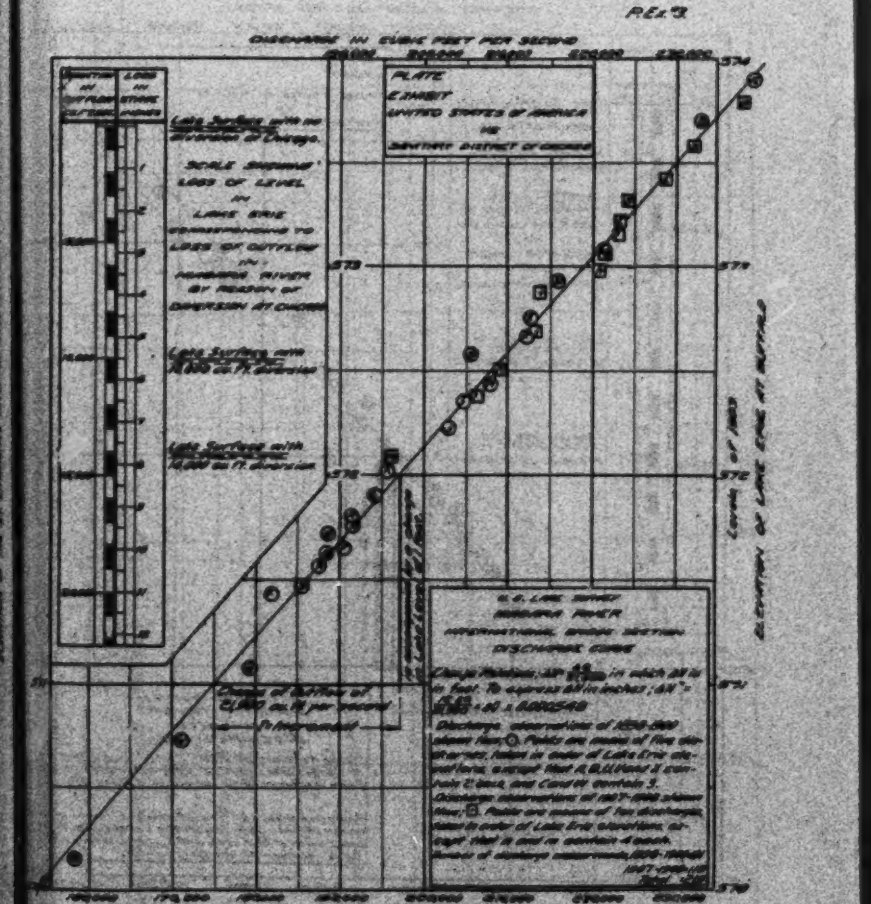


Williams Ex. 34. Plate II

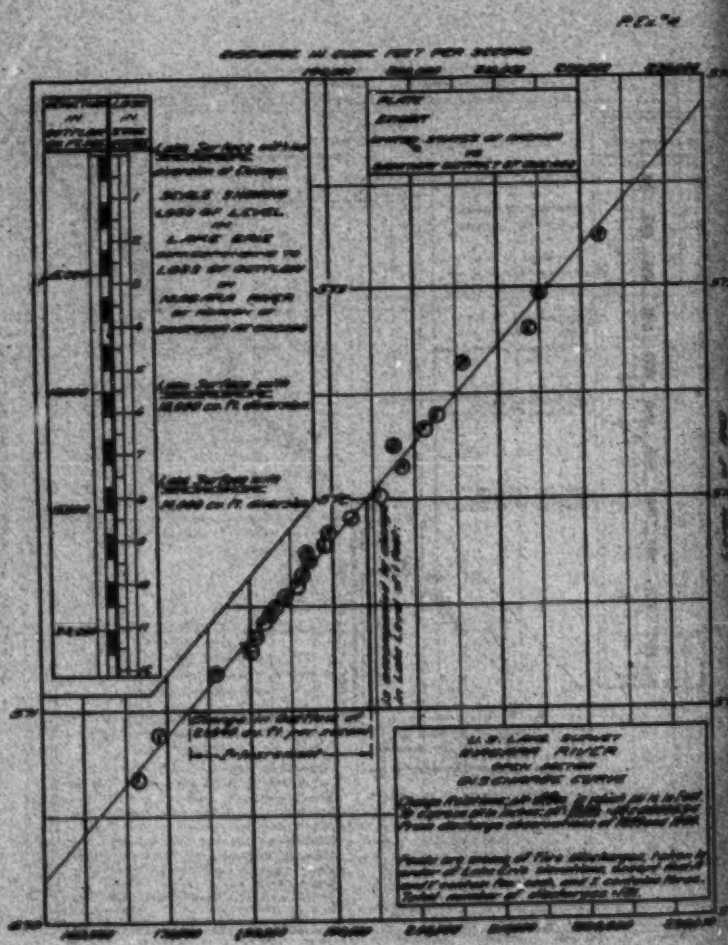
Pl. Ex. No. 2.



Williams Ex. 34. *Plate III*



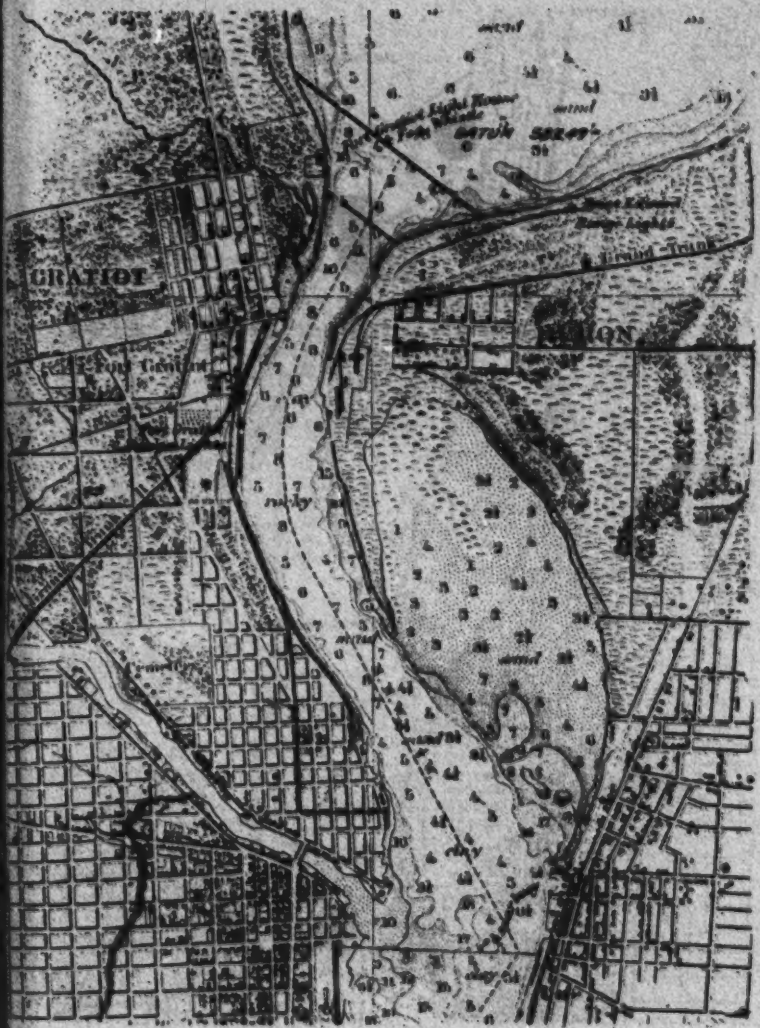
Williams Ex. 34. *Plate 2*



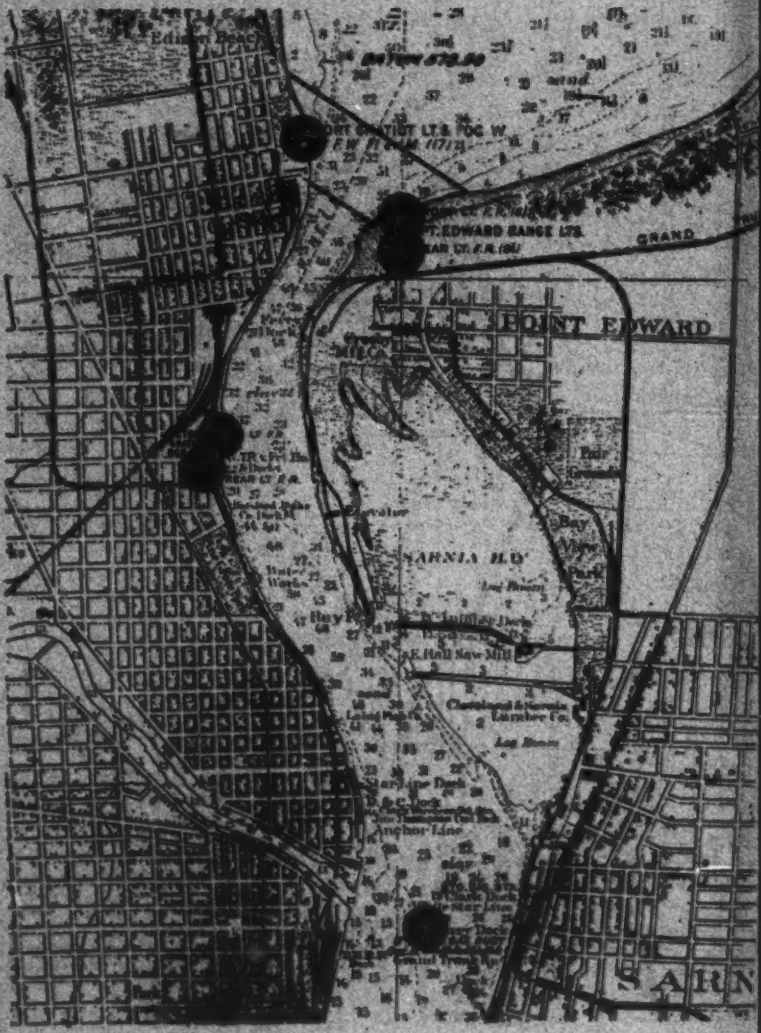
Williams Ex 34. Plate V

Williams Ex. 34. Plate II

Williams Ex. 34. Plate III.



Williams Ex 34 Plate III



Williams Ex. 34.

Plate IX

Chicago Sanitary District

CROSS SECTIONS

St. Clair River

Niagara River
Bridge Section

Niagara River
Open Section

St. Lawrence River

Sanitary District Canal

Scale 1" = 250'

Williams Ex. 34

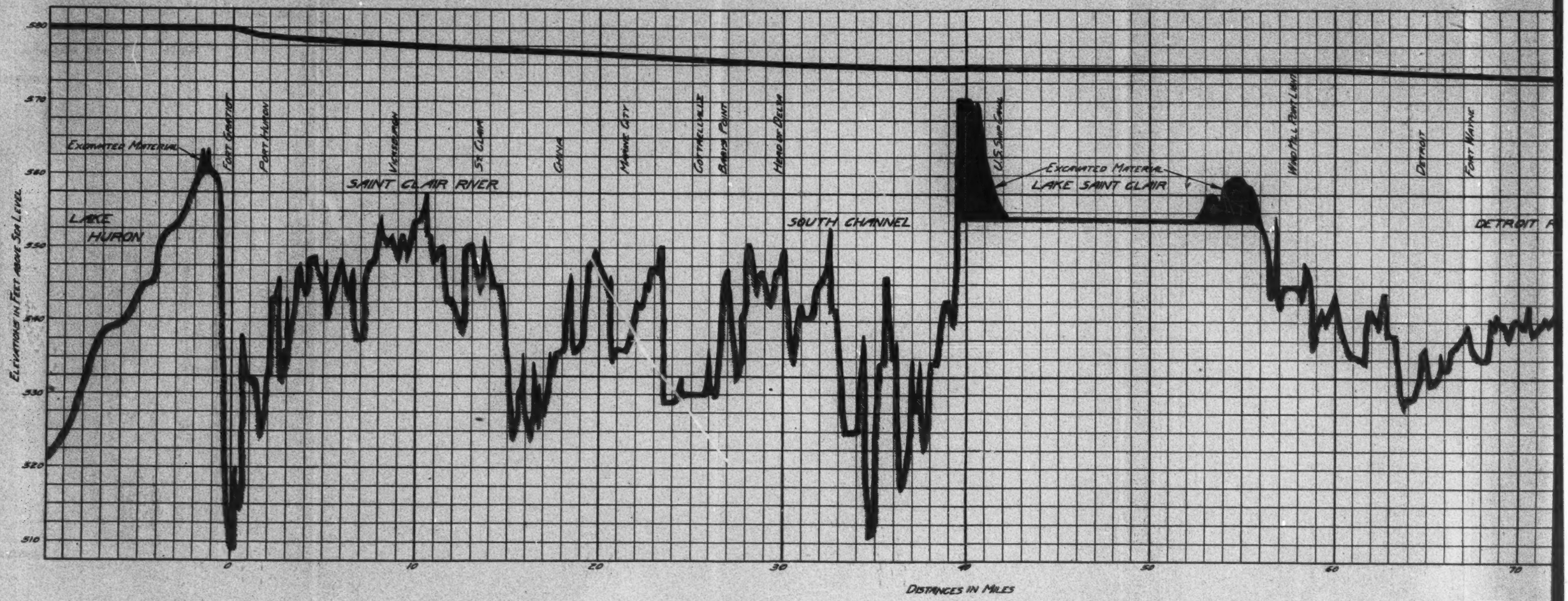
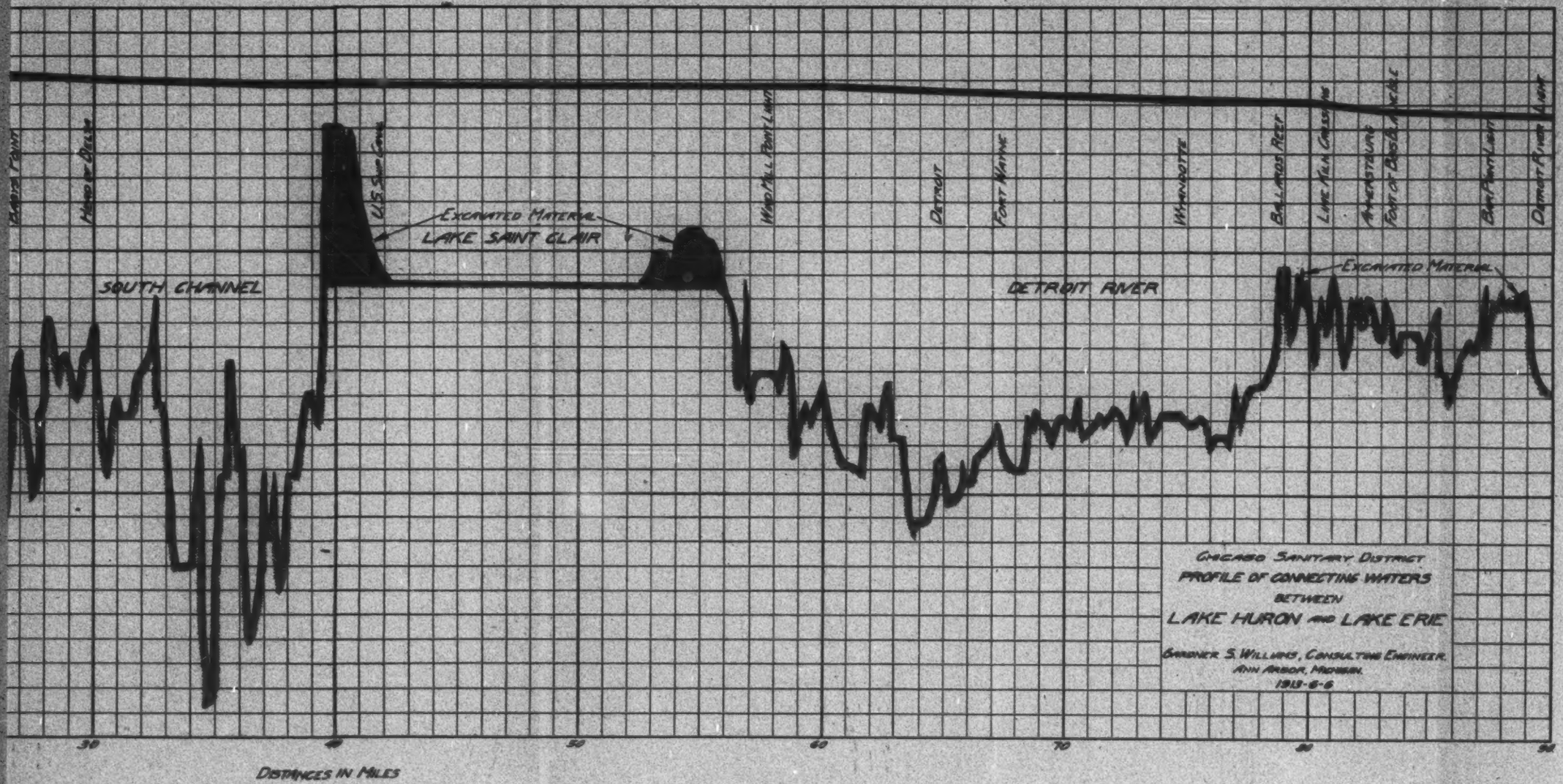


Plate X.

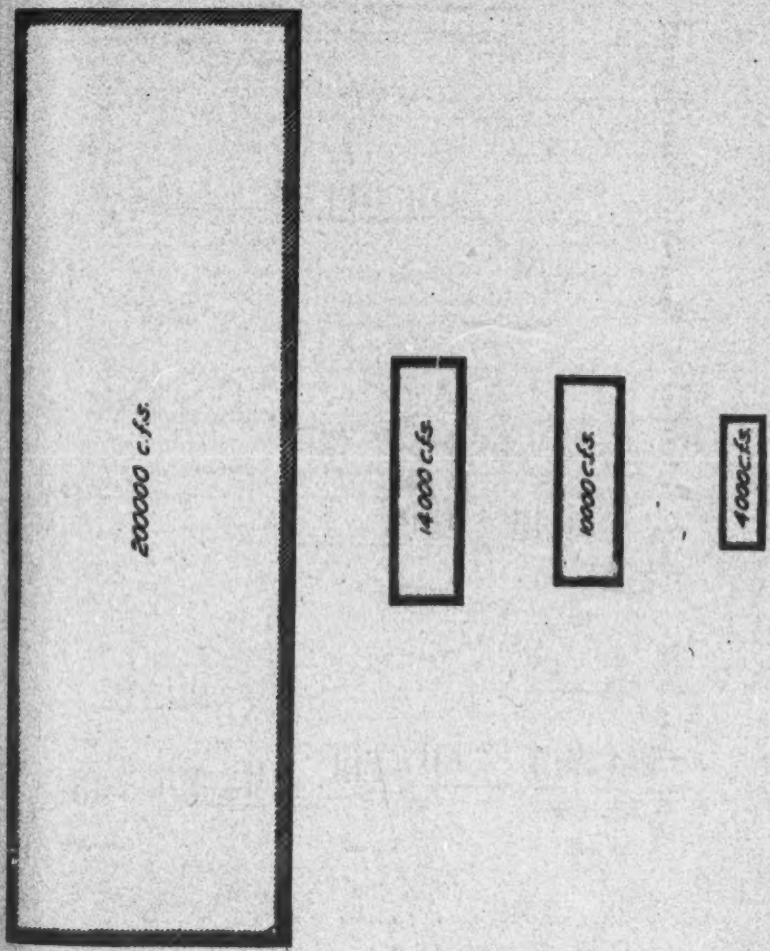


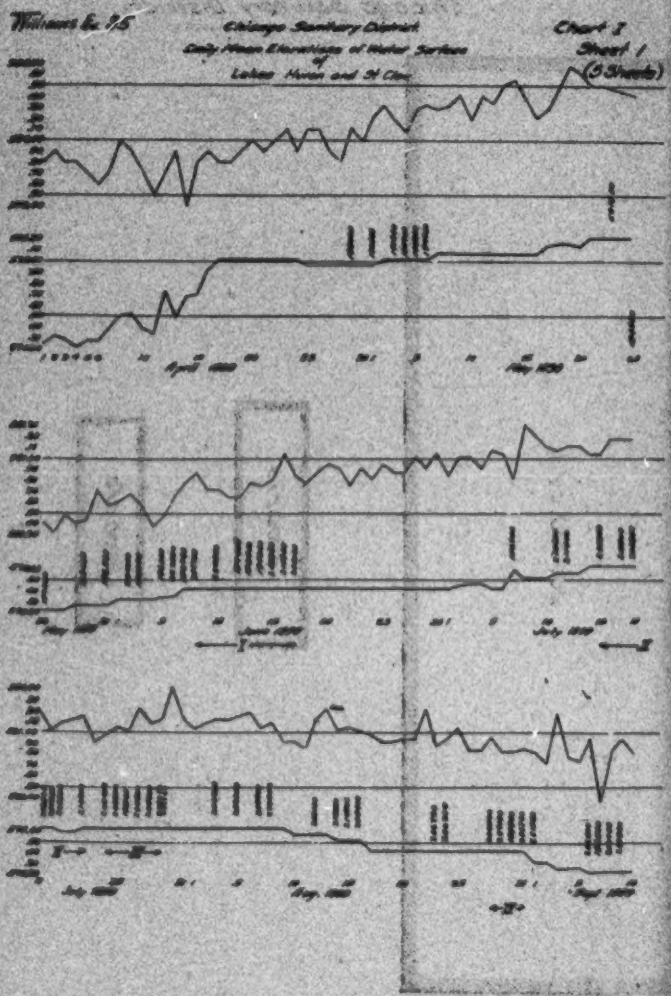
Chicago Sanitary District
PROFILE OF CONNECTING WATERS
BETWEEN
LAKE HURON AND LAKE ERIE

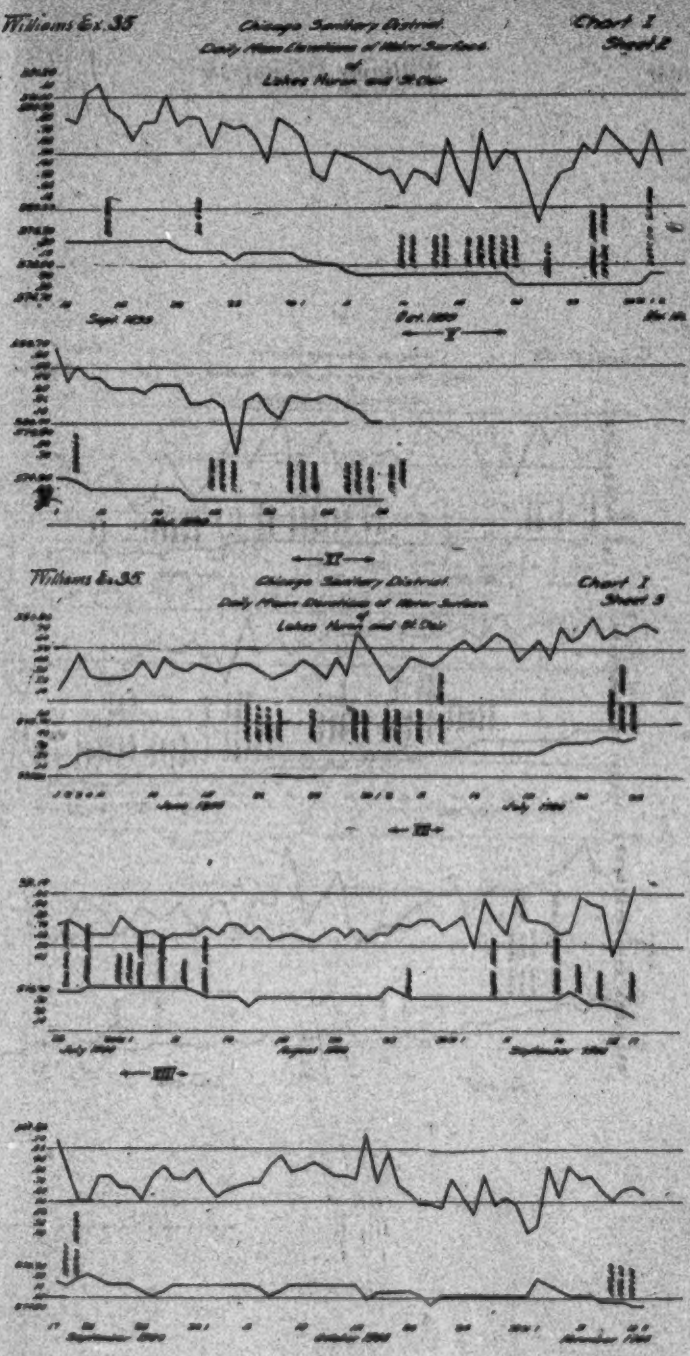
Gardner S. Williams, Consulting Engineer.
Ann Arbor, Michigan.
1913-6-6

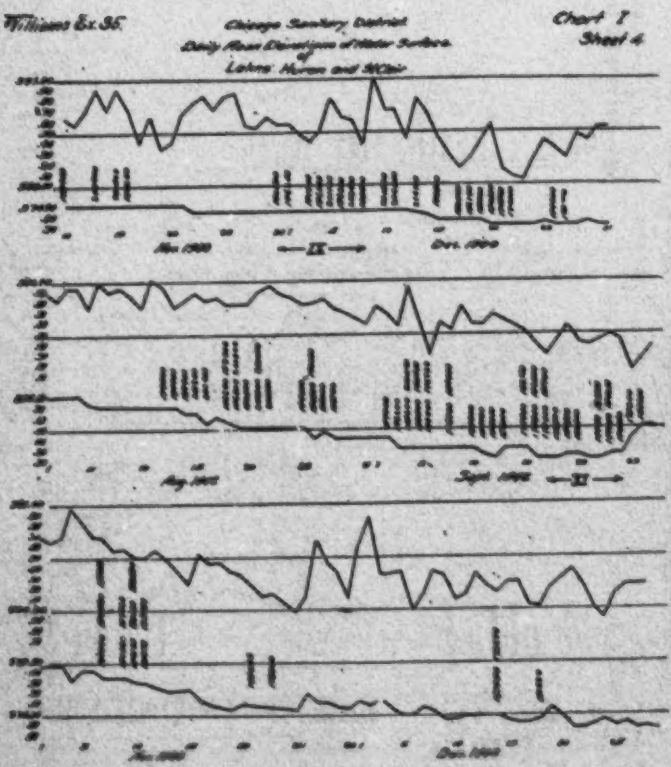
Plate XI

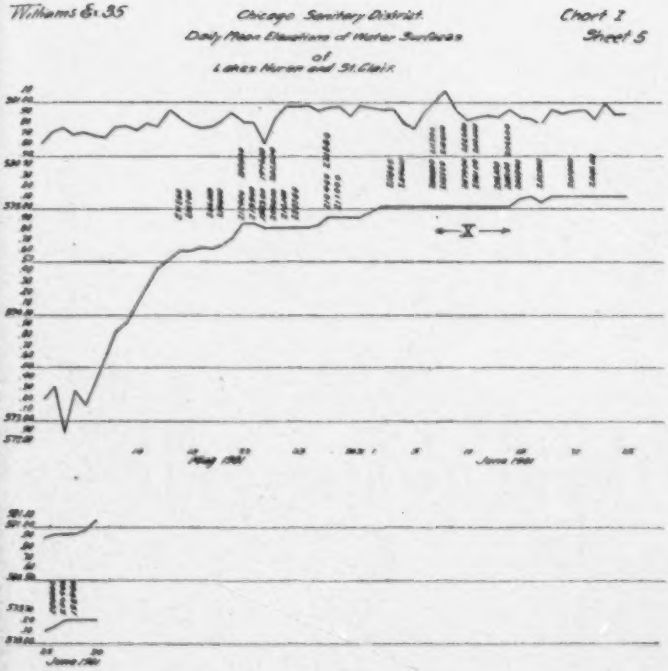
Chicago Sanitary District

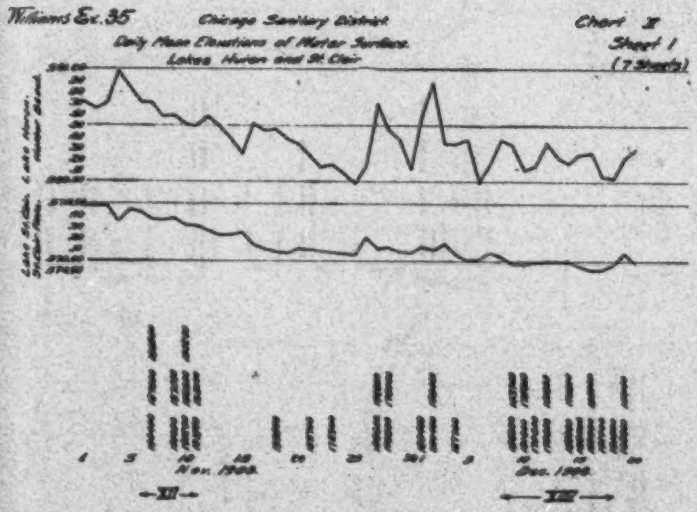


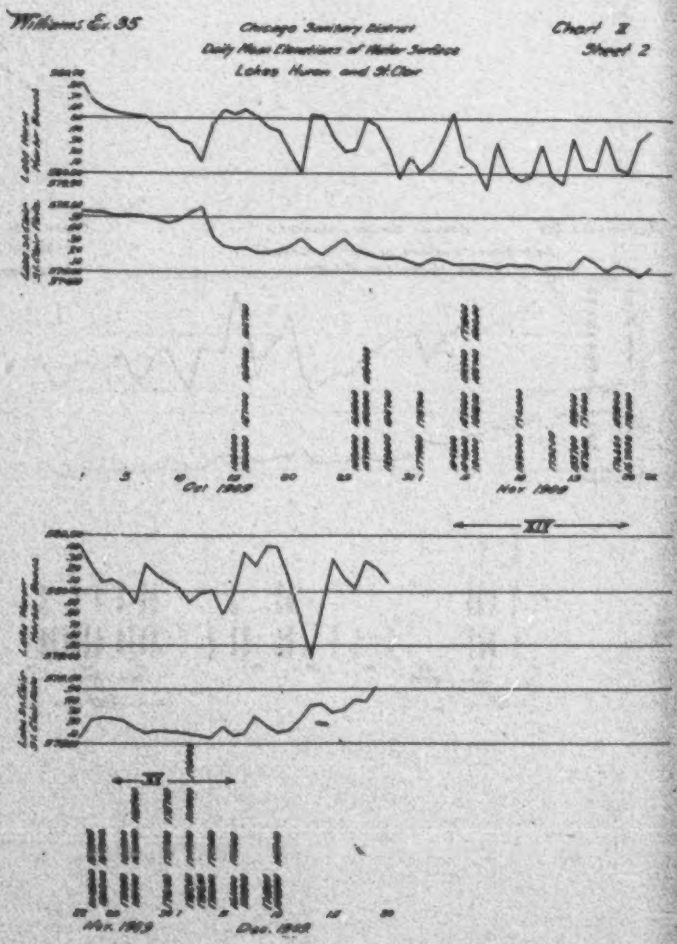

Williams Ex. 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface
of
Lakes Huron and St Clair
Chart I
Sheet 1
(3 Sheets)

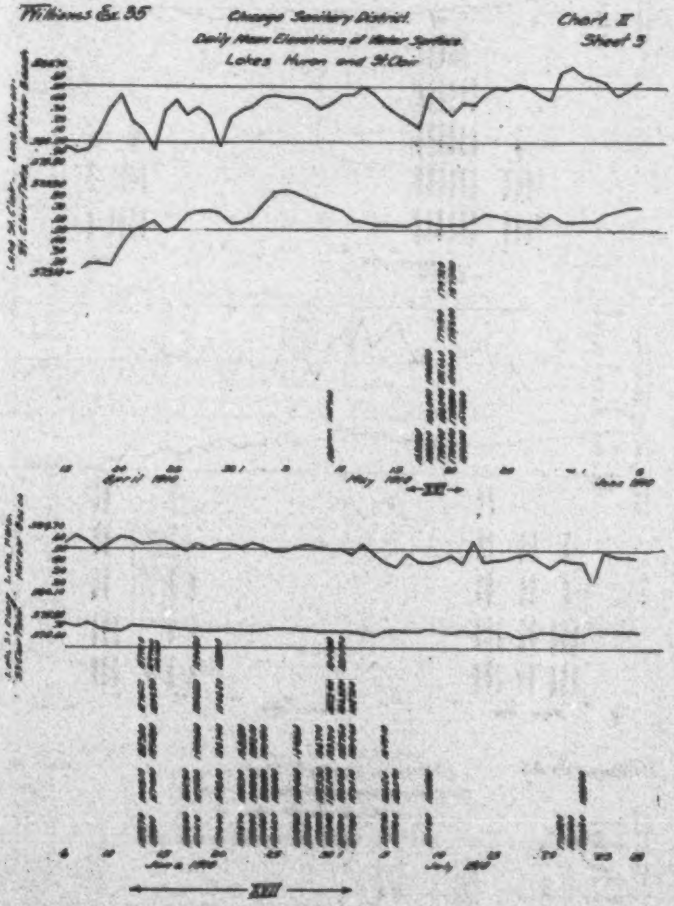

Williams Ex. 35
Chicago Sanitary District
Chart I
Sheet 2
Lakes Huron and St Clair
Williams Ex. 35
Chicago Sanitary District
Chart I
Sheet 3
Lakes Huron and St Clair

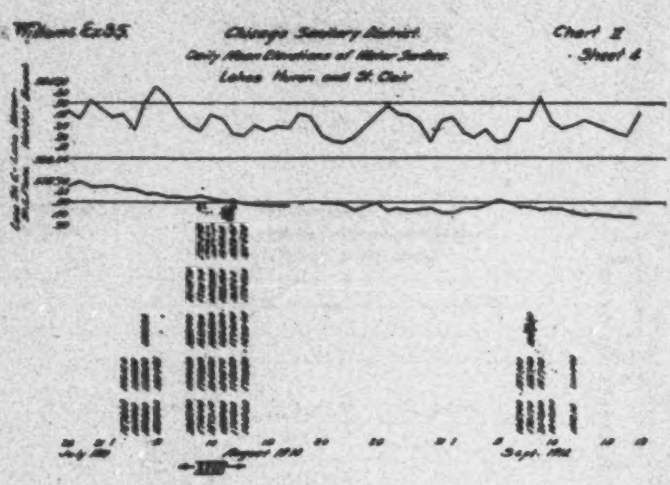

Williams Ex. 35.
Chicago Sanitary District
Chart 1
Sheet 4
of
Lakes Huron and Michigan

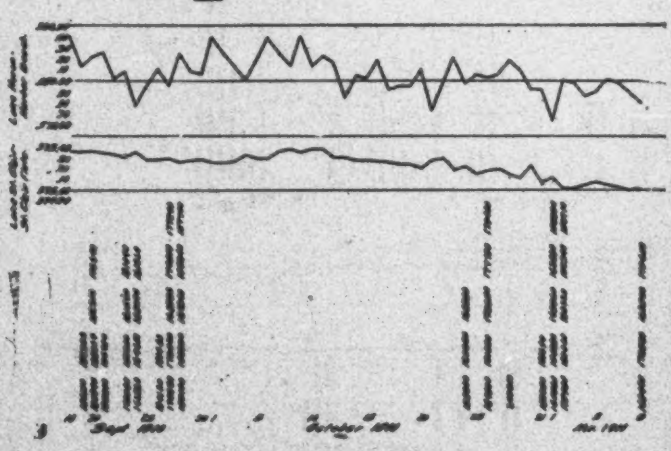

Williams Ex. 35
Chicago Sanitary District
Daily Mean Elevations of Water Surfaces
of
Lakes Huron and St. Clair
Chart 1
Sheet 5
X
May 1911
June 1911
June 1911

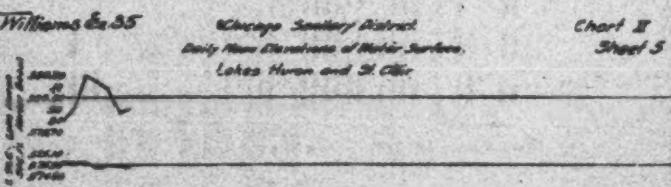

Williams Ex. 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface.
Lakes Huron and St. Clair
Chart X
Sheet 1
(7 Sheets)
Nov. 1900.
Dec. 1900.
XII
XIII

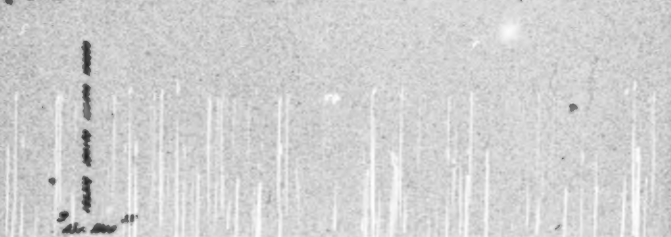

Williams Ex. 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface
Lakes Huron and St. Clair
Chart X
Sheet 2
Oct. 1909
Nov. 1909
XII
XII
Nov. 1909
Dec. 1909

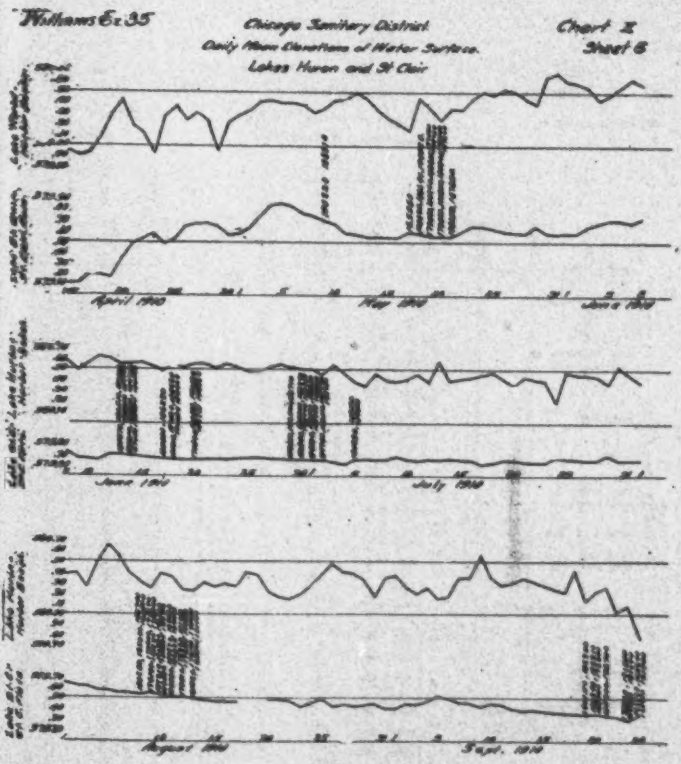

Williams Ex. 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface
Lakes Huron and St. Clair
Chart II
Sheet 3
XII
XIII


Williams Ex 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface
Lakes Huron and St. Clair
Chart II
Sheet 4




Williams Ex 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface
Lakes Huron and St. Clair
Chart II
Sheet 5




Williams Ex 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface.
Lakes Huron and St Clair
Chart II
Sheet 6
April 1910
May 1910
June 1910
June 1910
July 1910
August 1910
Sept. 1910
Williams Ex 35
Chicago Sanitary District
Daily Mean Elevations of Water Surface.
Lakes Huron and St Clair
Chart II
Sheet 7
Sept 1910
October 1910

Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Cleveland
Chart III
Sheet 1
(4 Sheets)
III
II
I
II
III
Sept 1838
Nov 1838
Dec 1838
July 1838
Aug 1838
Sept 1838
Oct 1838
July 1838
Aug 1838
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
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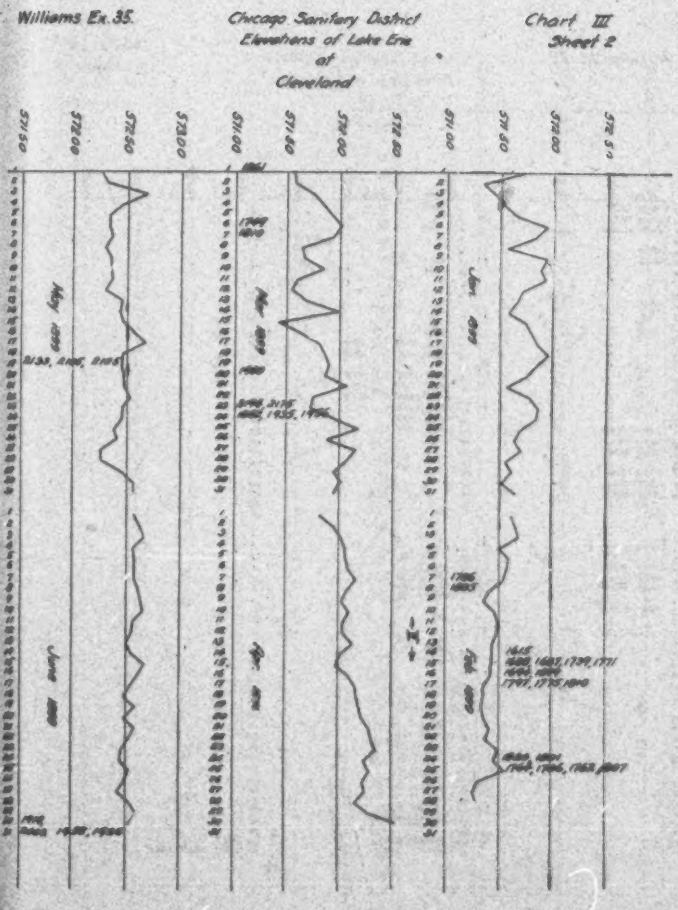
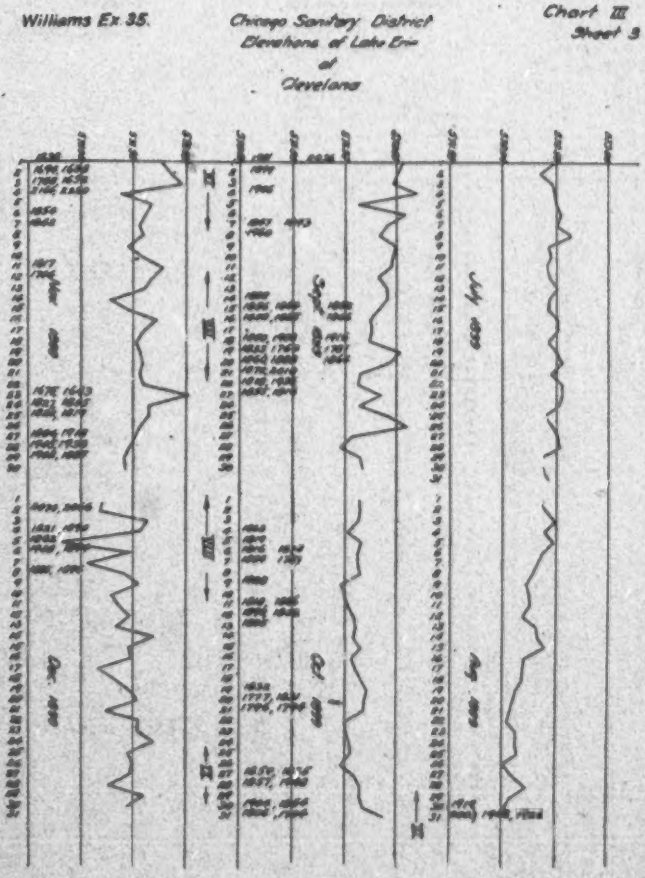
1967
1968
1969
1970
1971
1972


Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Cleveland
Chart III
Sheet 2
574.0
573.0
572.0
571.0
570.0
569.0
568.0
567.0
566.0
565.0


Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Cleveland
Chart III
Sheet 3

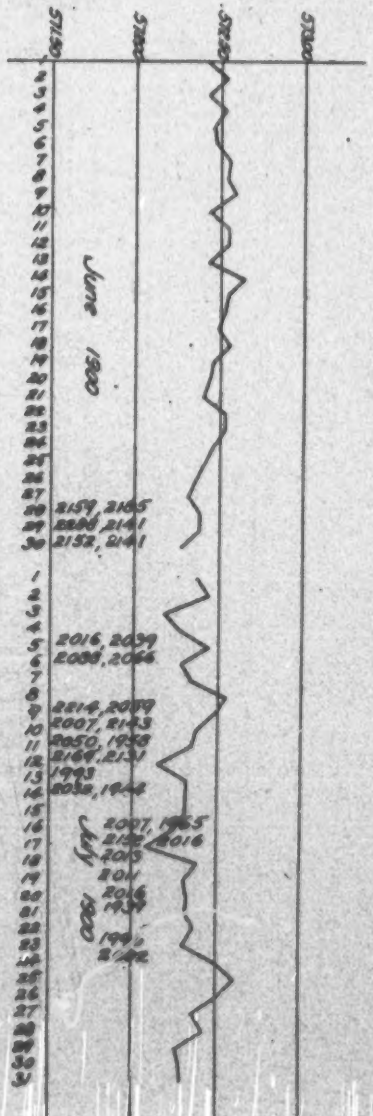
Williams Exhibit 35.

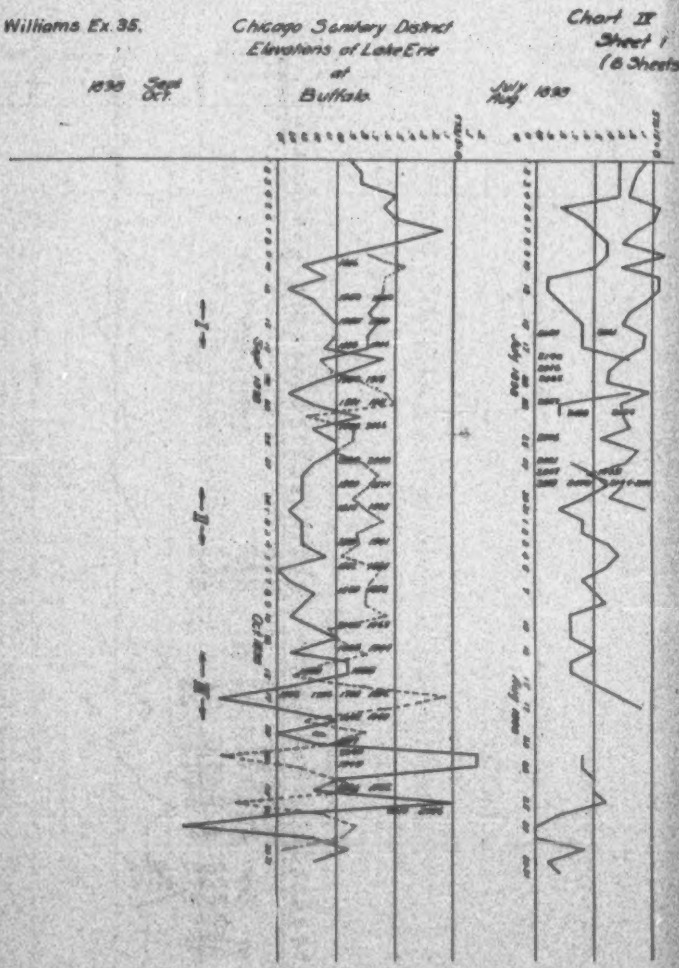
Chicago Sanitary District

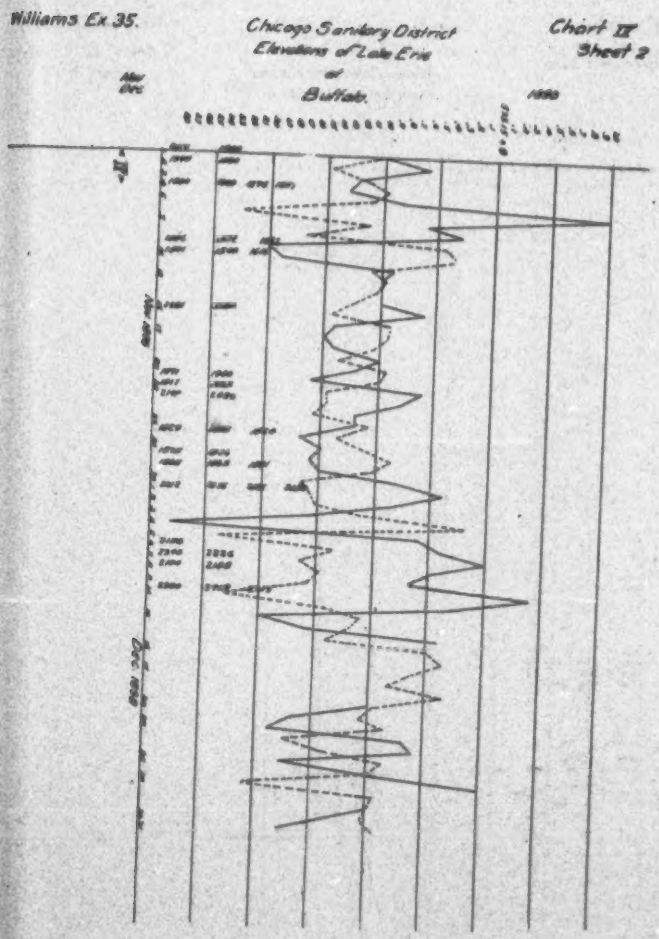
Williams Ex. 35. Elevations of Lake Erie at Cleveland

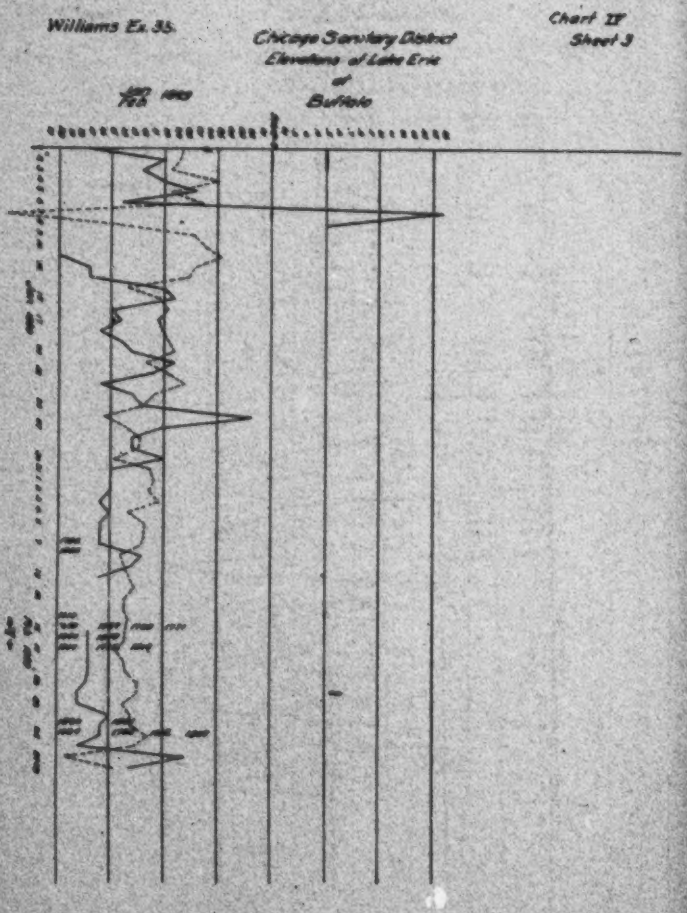
Chart III

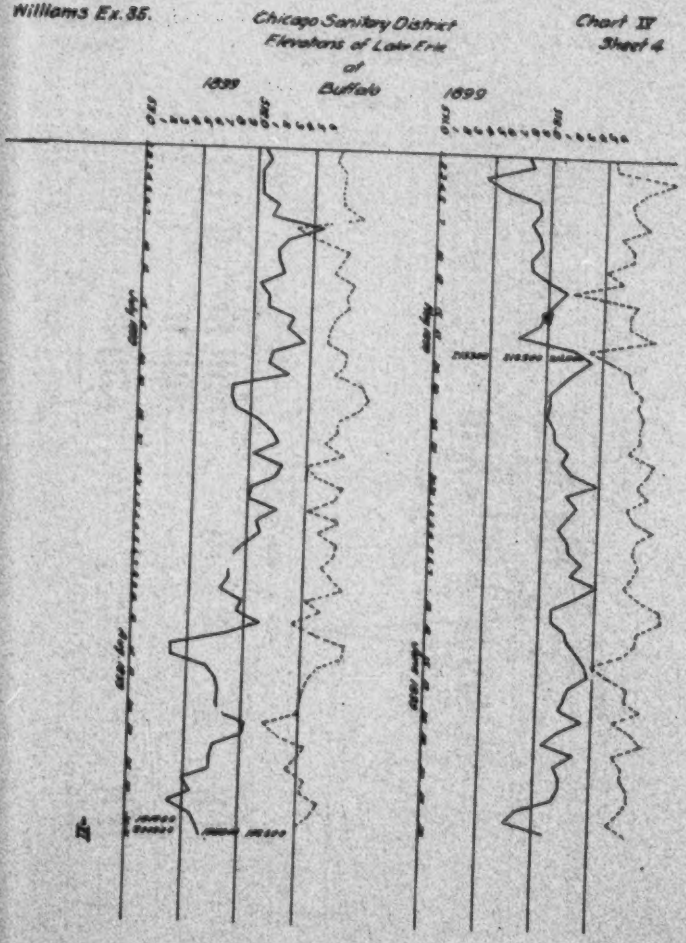
Sheet 4

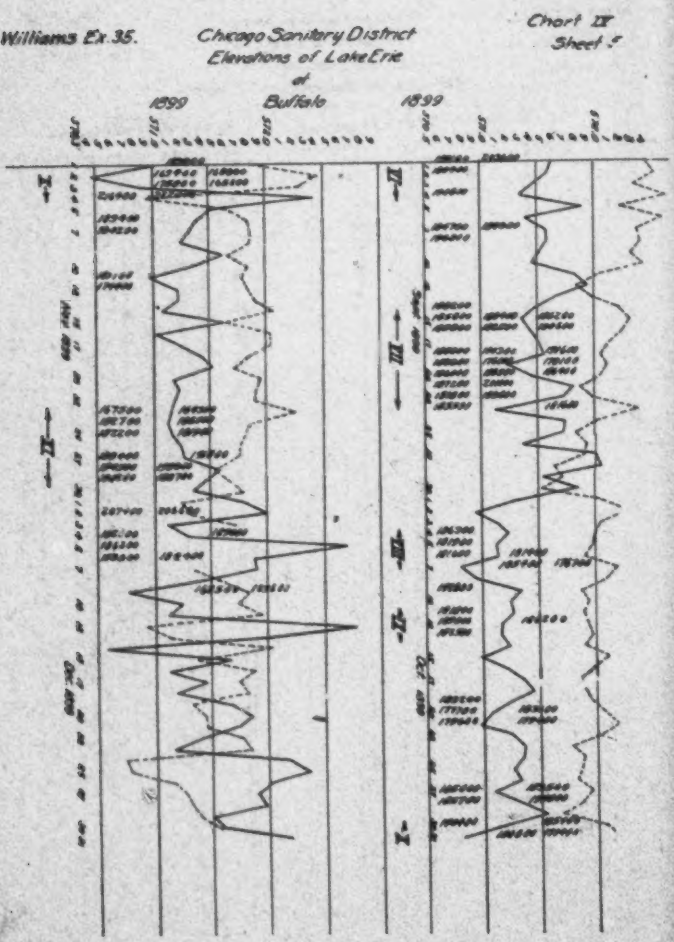


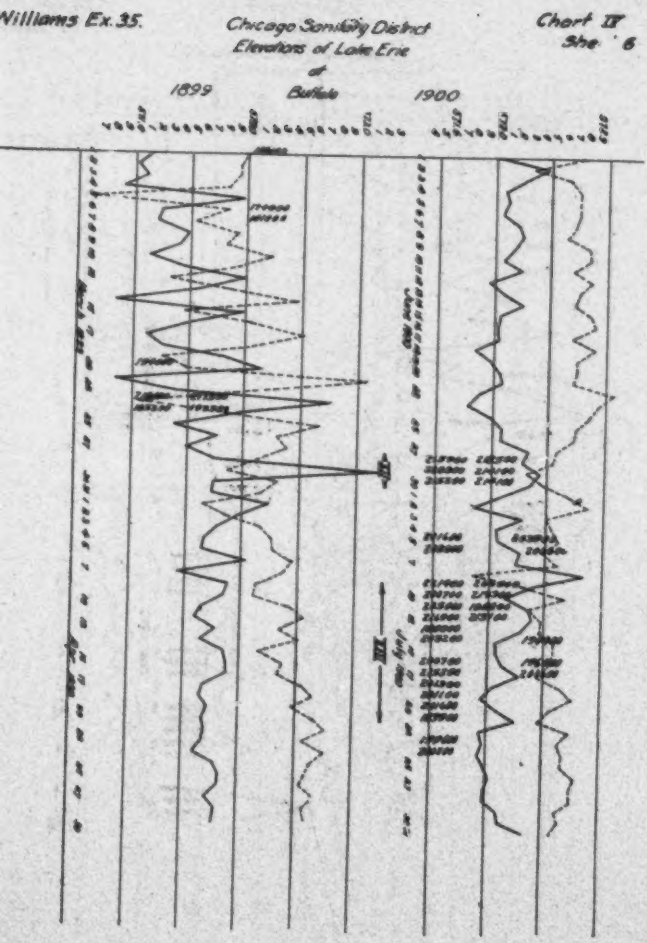

Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo.
Chart II
Sheet 1
(6 Sheets)
1896 Sept Oct.
July Aug. 1899
I
II
III


Williams Ex 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo.
Chart II
Sheet 2


Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo
Chart II
Sheet 3


Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo
Chart IV
Sheet 4
1839
1899

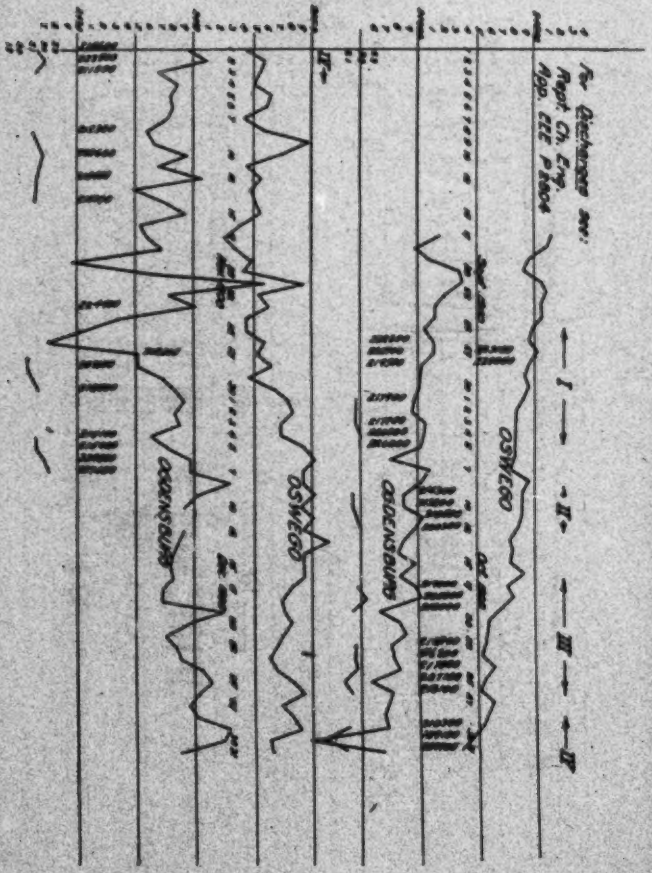

Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo
1899
1899
Chart IX
Sheet 5

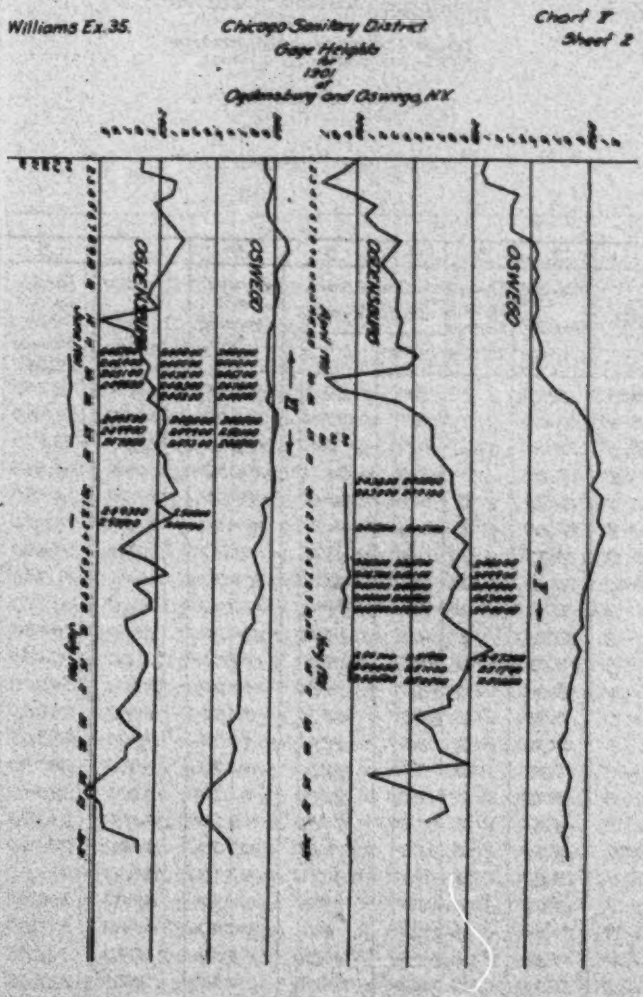

Williams Ex. 35.
Chicago Sanitary District
Elevations of Lake Erie
at
Buffalo
Chart II
Sheet 6
1899
1900

Williams Ex. 35.

The Chicago Sanitary District
Gage Heights
at
Oswego and Oswego, N.Y.

Chart I
Sheet 1
(2 Sheets)




Williams Ex. 35.
Chicago Sanitary District
Gage Heights
for
1901
at
Oakwood and Oswego, N.Y.
Chart I
Sheet 2
OSWEGO
OSWEGO
OSWEGO

Steam's Exhibit 9,
Table A

Chicago Sanitary District
Local Supply and Storage
Lake Ontario

June - Nov. 1883 - 1906

1	2	3	4	5	6	7	8
Year	Rainfall Ontario Inches	Evaporation Ontario Inches	Excess of Evaporation Inches	Excess of Evaporation C.F.S.	Runoff into Ontario C.F.S.	Storage Ontario C.F.S.	Total Local Supply & Storage C.F.S.
1883	18.96	21.8	+2.82	+ 3010	-13100	- 6660	-18750
4	16.43	21.8	+5.37	+ 5740	-13100	-24600	-31960
5	22.36	21.8	-0.56	- 597	-17800	- 1280	-19670
6	18.89	21.8	+2.91	+ 3110	-15050	-26640	-38580
7	15.36	21.8	+6.44	+ 6860	-12200	-29440	-34780
8	20.68	21.8	+1.12	+ 1195	-16450	-10760	-26000
9	23.75	21.8	-3.95	- 4215	-20500	-13080	-37800
1890	26.32	21.8	-4.52	- 4820	-20900	-13640	-41360
1	18.78	21.8	+3.02	+ 3240	-14950	-33360	-45270
2	23.20	21.8	-1.40	- 1490	-18450	- 3460	-23400
3	19.08	21.8	+2.72	+ 2905	-13200	-25100	-37400
4	18.54	21.8	+3.26	+ 3480	-14750	-22800	-34070
5	15.93	21.8	+5.87	+ 6270	-12680	-19480	-25900
6	18.76	21.8	+3.04	+ 3245	-14900	-18200	-29860
7	17.82	21.8	+3.98	+ 4250	-14200	-13380	-23330
8	19.72	21.8	+2.08	+ 2220	-15700	-15360	-28840
9	14.51	21.8	+7.29	+ 7780	-11550	-20620	-24390
1900	19.74	21.8	+2.06	+ 2200	-15700	-16000	-29500
1	18.03	21.8	+3.77	+ 4020	-14350	-20860	-31190
2	21.03	21.8	+0.77	+ 822	-16750	- 6920	-22830
3	21.04	21.8	+0.76	+ 811	-16750	-16140	-32080
4	17.88	21.8	+3.92	+ 4180	-14200	-21240	-31260
5	21.56	21.8	+0.24	+ 256	-17150	- 3620	-22500
6	21.20	21.8	+0.54	+ 576	-16900	- 9480	-25800

Chicago Sanitary District Stearns Exhibit
Local Supply and Storage Table B
Lakes St. Clair and Erie

June - Nov. 1883 - 1906

1	2	3	4	5	6	7	8
Year	Rainfall St. Clair Erie Inches	Evaporation St. Clair Erie Inches	Excess of Evaporation Inches	Excess of Evaporation C.F.S.	Runoff St. Clair and Erie C.F.S.	Storage St. Clair and Erie C.F.S.	Total Local Supply & Storage C.F.S.
1883	20.90	24.4	+3.50	+ 5400	- 18600	- 9400	- 22600
4	14.78	24.4	+9.62	+14800	- 13160	- 29540	- 27900
5	22.57	24.4	+ 1.83	+ 2800	- 20060	- 3140	- 20400
6	17.06	24.4	+7.34	+11300	- 15200	- 17900	- 21800
7	14.87	24.4	+9.53	+14650	- 13240	- 29510	- 28100
8	16.38	24.4	+8.02	+12320	- 14590	- 12730	- 15000
9	14.91	24.4	+9.49	+14600	- 13300	- 15700	- 14400
1890	20.06	24.4	+4.34	+ 6680	- 17900	- 21080	- 32300
1	18.47	24.4	+5.93	+ 9130	- 16430	- 23100	- 30400
2	19.95	24.4	+4.45	+ 6850	- 17760	- 21790	- 32700
3	13.84	24.4	+8.56	+13180	- 14110	- 29170	- 30100
4	14.02	24.4	+10.38	+13930	- 12300	- 19050	- 15800
5	14.93	24.4	+9.47	+14380	- 13300	- 13480	- 12200
6	21.56	24.4	+2.84	+ 4370	- 19210	- 12760	- 27600
7	17.45	24.4	+6.95	+10690	- 15540	- 18850	- 23700
8	19.98	24.4	+4.42	+ 6810	- 17790	- 21420	- 32400
9	14.01	24.4	+10.39	+16040	- 12490	- 18650	- 15100
1900	19.50	24.4	+4.90	+ 7540	- 17370	- 17170	- 27000
1	15.79	24.4	+8.61	+13250	- 14050	- 5900	- 6700
2	23.57	24.4	+0.83	+ 1260	- 21000	- 1260	- 21000
3	19.79	24.4	+4.61	+ 7100	- 17620	- 27380	- 37900
4	14.89	24.4	+9.55	+14700	- 13240	- 23560	- 22100
5	21.08	24.4	+3.32	+5100	- 18800	- 14600	- 28300
6	20.78	24.4	+3.62	+ 5570	- 18500	- 3870	- 16800

Stearns Exhibit 1
Table C

Chicago Sanitary District

Comparison of Discharges
Niagara River
June - Nov. 1883-1900

Comparison of Niagara River Discharge as deduced from St. Lawrence River with Tabulated Discharge, using at both places the Discharge of the International Waterways Comm.

1	2	3	4	5	6	7
Year	St. Lawrence River Discharge I.W.W.C. C.F.S.	Total Local Supply Lake Ontario C.F.S.	Deduced Niagara Discharge C.F.S.	Niagara Discharge I.W.W.C C.F.S.	Col. 4 minus Col. 3	
1883	296100	18700	277400	239700	37700	
4	297000	32000	265000	231800	33200	
5	285200	19700	265500	241200	24300	
6	287500	38600	248900	235300	13600	
7	279100	34800	244300	230600	13700	
8	230000	26000	224000	216300	7700	
9	261900	37800	224100	209700	14400	
1890	290900	41400	249500	225200	24300	
1	243300	43300	200000	199100	900	
2	245800	23400	222400	215700	6700	
3	272100	37400	234700	210000	24700	
4	230100	34100	216000	205600	10400	
5	195200	25900	169300	181700	-12400	
6	203000	29900	173100	189600	-16500	
7	217700	23300	194200	200400	-6200	
8	234800	28800	226000	202700	23300	
9	237500	24400	213400	196400	17300	
1900	234200	29300	204700	199200	5500	
1	235700	31900	204500	188800	15700	
2	243000	22800	220700	206900	13300	
3	235900	32100	223800	209800	14000	
4	273900	31300	242600	218800	23800	
5	263200	22500	240700	216000	24700	
6	244700	25800	218900	205400	13500	

Average excluding years 1895-96 16390

Stearns Exhibit 7.
Table D

Chicago Sanitary District
Comparison of Discharges
Niagara River
June - Nov. 1883 - 1908

Comparison of Niagara River Discharge as deduced from St. Lawrence River with Tabulated Discharge, using for St. Lawrence Defendant's Equation, for Niagara International Waterways Comm.

1	2	3	4	5	6
Year	St. Lawrence River Discharge Defendant's Equation C.F.S.	Total Local Supply Stmr. Ontario C.F.S.	Deduced, Niagara Discharge C.F.S.	Niagara Discharge I.W.W.C. C.F.S.	Col. 4 minus Col. 5 C.F.S.
1883	296500	- 18700	277800	239700	38100
4	296900	- 32000	264900	231800	33100
5	293700	- 19700	274000	241200	32800
6	298800	- 38600	260200	233300	26900
7	287600	- 34800	252800	230600	22200
8	252800	- 28000	226800	216300	10500
9	258600	- 37800	220800	209700	11100
1890	292100	- 41400	250700	225200	25500
1	247700	- 43300	202400	199100	3300
2	249300	- 23400	225900	215700	10200
3	267500	- 37400	230100	210000	20100
4	230300	- 34100	216200	205600	10600
5	199200	- 25900	173300	181700	- 8400*
6	214800	- 29900	184900	189600	- 4700*
7	228600	- 23500	205100	200400	4700
8	236200	- 28800	207400	202700	4700
9	231400	- 24400	207000	196400	10600
1900	231800	- 29300	202300	199200	3100
1	229500	- 31200	198300	188800	9500
2	242900	- 22800	220100	204900	15200
3	255100	- 32100	223000	209800	13200
4	282400	- 31300	251100	218800	42300*
5	272300	- 22900	249800	216000	33800*
6	234100	- 25800	228300	205400	27900*
				Mean	16070

* Defective due to low stages of lakes in 1895-98 and to Cut Dam in 1904-5-6 and therefore omitted from mean.

Stearns Exhibit 1.
Table E

Chicago Sanitary District
Comparison of Discharges
St. Clair River
June-Nov. 1883-1906

Comparison of St. Clair River Discharges as deduced from Niagara River with Computed Discharge, Using International Waterways Comm. Niagara Discharge, Complainant's Equation St. Clair River

1	2	3	4	5	6	7
Year	Niagara Discharge I.W.W.C. C.F.S.	Total Local Supply and Storage St. Clair Erie C.F.S.	Deduced St. Clair Discharge C.F.S.	St. Clair Discharge Complainant's Equation C.F.S.	Col. 5 minus Col. 4 C.F.S.	
1883	239700	-22600	217100	249400	32300	
4	231800	-27900	203900	245800	41900	
5	241200	-20400	220800	253400	32600	
6	233300	-21800	211500	254800	43300	
7	230600	-28100	202500	237200	34700	
8	216500	-13000	201300	227400	26100	
9	209700	-14400	195300	212700	17400	
1890	225200	-32300	192900	212200	19300	
1	199100	-30400	168700	192200	23500	
2	213700	-32700	183000	195800	12800	
3	210000	-30100	179900	201200	21300	
4	205600	-13600	190000	203100	13100	
5	181700	-12200	169500	173000	3500	
6	189600	-27600	162000	173400	11400	
7	200400	-23700	176700	190500	13800	
8	202700	-32400	170300	190300	20000	
9	196400	-13100	181300	194800	13500	
1900	199200	-27000	172200	191700	19500	
1	188800	-6700	182100	197900	15800	
2	204900	-21000	183900	189800	5900	
3	209800	-37900	171900	194100	22200	
4	216800	-22100	196700	209900	13200	
5	216000	-28300	187700	210100	22400	
6	205400	-16800	188600	204800	16200	

Stearns Exhibit #1
Table F

Chicago Sanitary District.
Comparison of Discharges
St. Clair River
June - Nov. 1883 - 1906

Comparison of St. Clair River Discharges as deduced from Niagara River with Computed Discharge, using International Waterways Commission Niagara Discharge, Defendant's Equation St. Clair River.

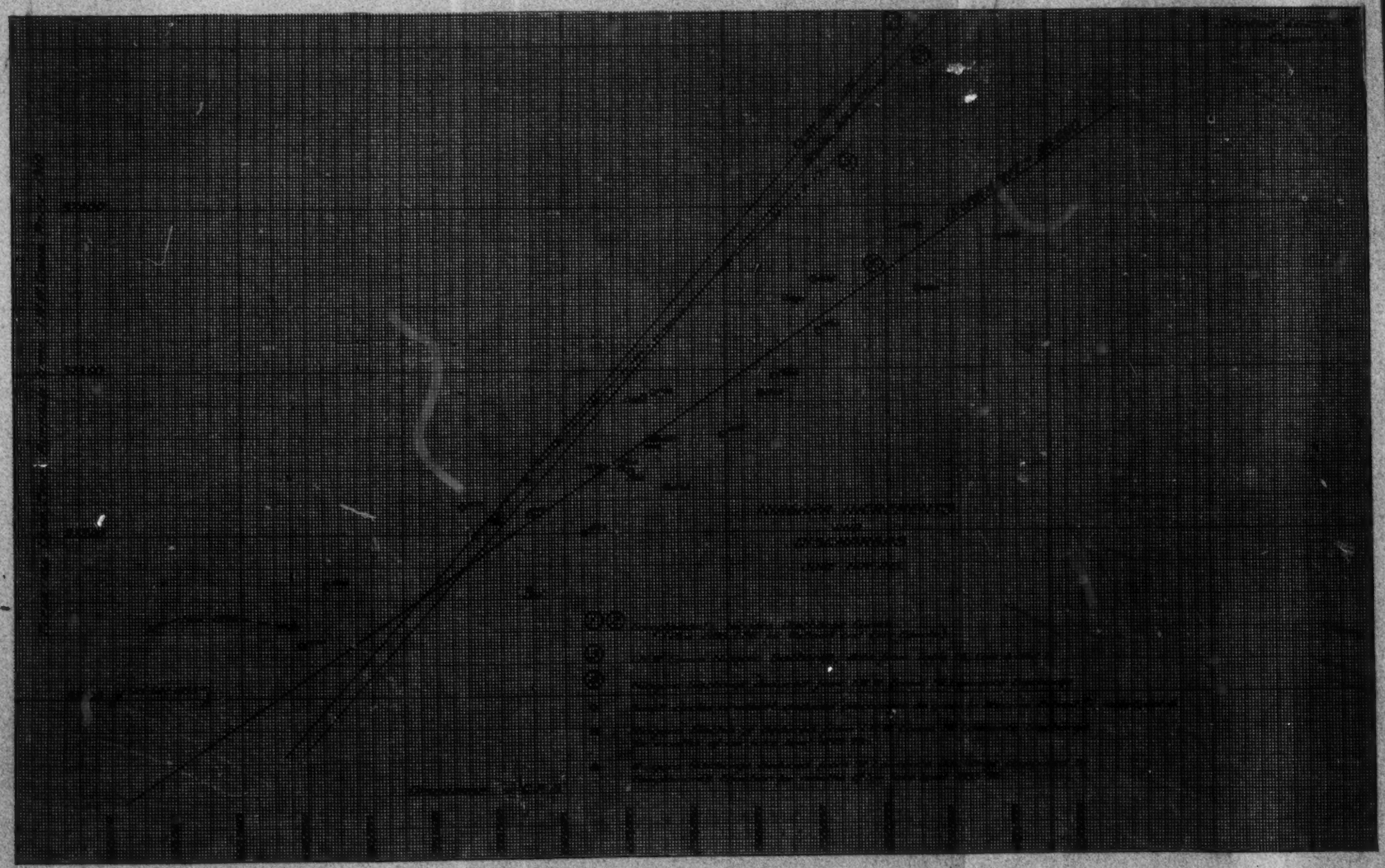
1	2	3	4	5	6	7
Year	Niagara Discharge I.W.W.C. C.F.S.	Total Local Supply and Storage St. Clair Erie C.F.S.	Deduced St. Clair Discharge C.F.S.	St. Clair Discharge Defendant's Equation C.F.S.	Col. 4 minus Col. 5 C.F.S.	Means.
1883	239700	-22600	217100	266600	49500	
4	231800	-27900	203900	264300	60400	
5	241200	-20400	220800	276600	55800	
6	233300	-21800	211500	280700	69200	
7	230600	-28100	202500	235400	32900	
8	216300	-15000	201300	244600	43300	55200
9	209700	-14400	195300	223800	28500	
1890	223200	-32300	192900	219500	26600	
1	199100	-30400	168700	196700	28000	
2	213700	-32700	183000	197400	14400	
3	210000	-30100	179900	206700	26800	
4	205600	-13600	190000	211000	21000	24200
5	181700	-12200	169500	176000	6500*	
6	189600	-27600	162000	169700	7700*	
7	200400	-23700	176700	193200	16500	
8	202700	-32400	170300	191500	21200	
9	196400	-13100	181300	199800	18500	
1900	199200	-27000	172200	195500	23300	
1	188800	- 6700	182100	206700	24600	
2	204900	-21000	183900	189800	5900	
3	209800	-37900	171900	195400	23500	
4	218800	-22100	196700	216000	19300	
5	216000	-28300	187700	218300	30600	
6	205400	-18800	188600	211900	23300	20700

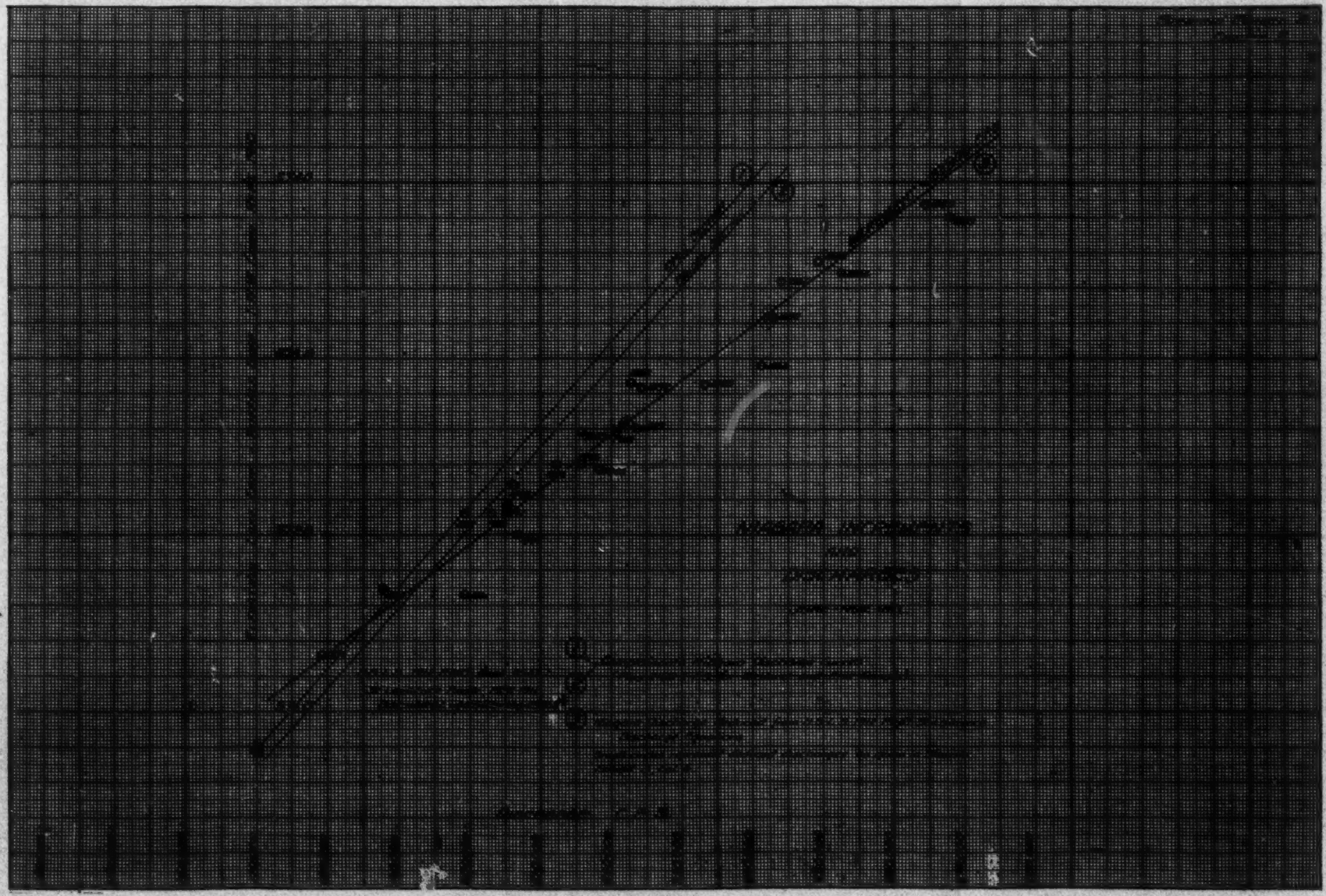
* Defective due to low stage of Lakes.

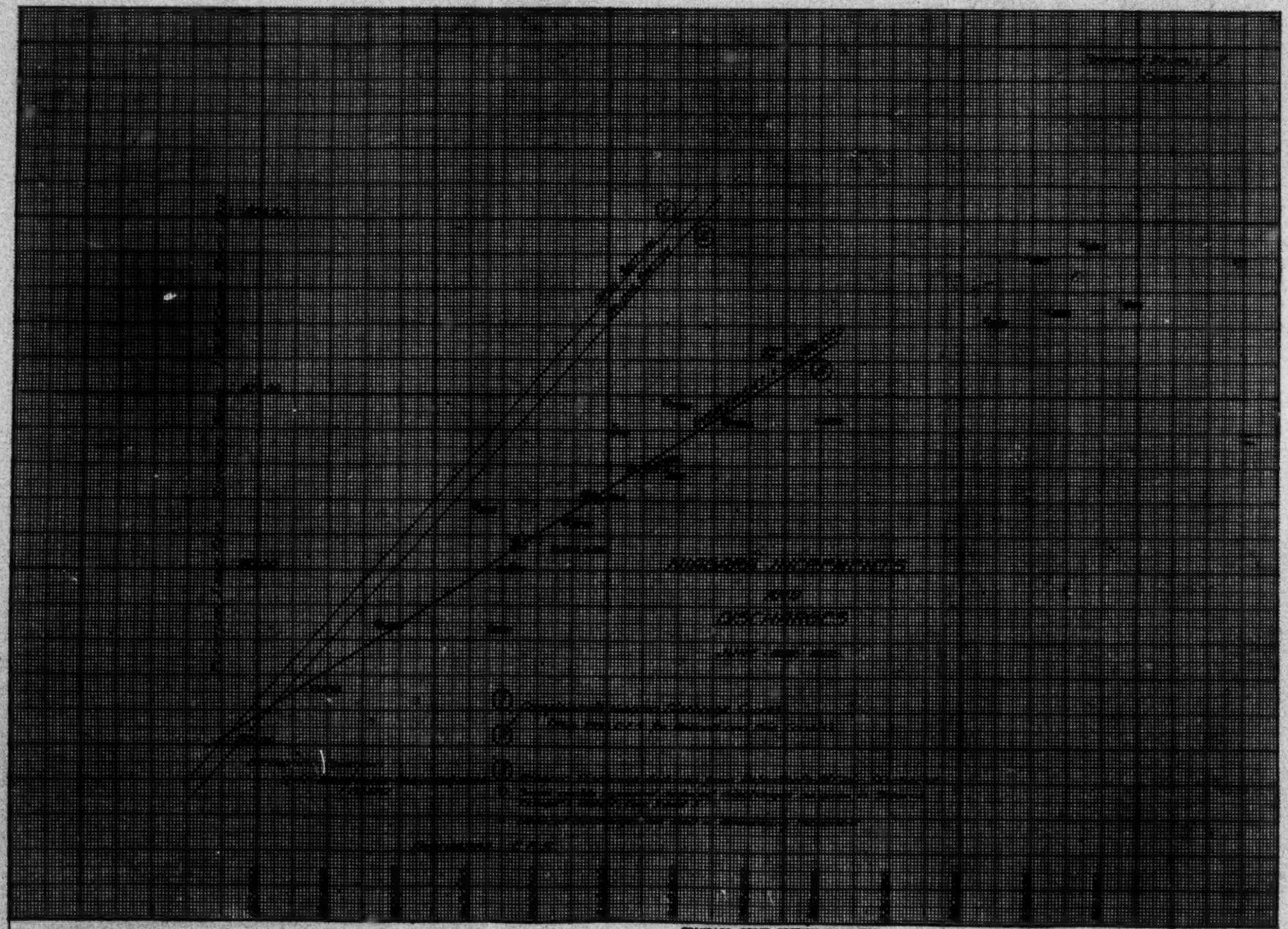
Stearn's Exhibit #1
Table 6
Chicago Sanitary District

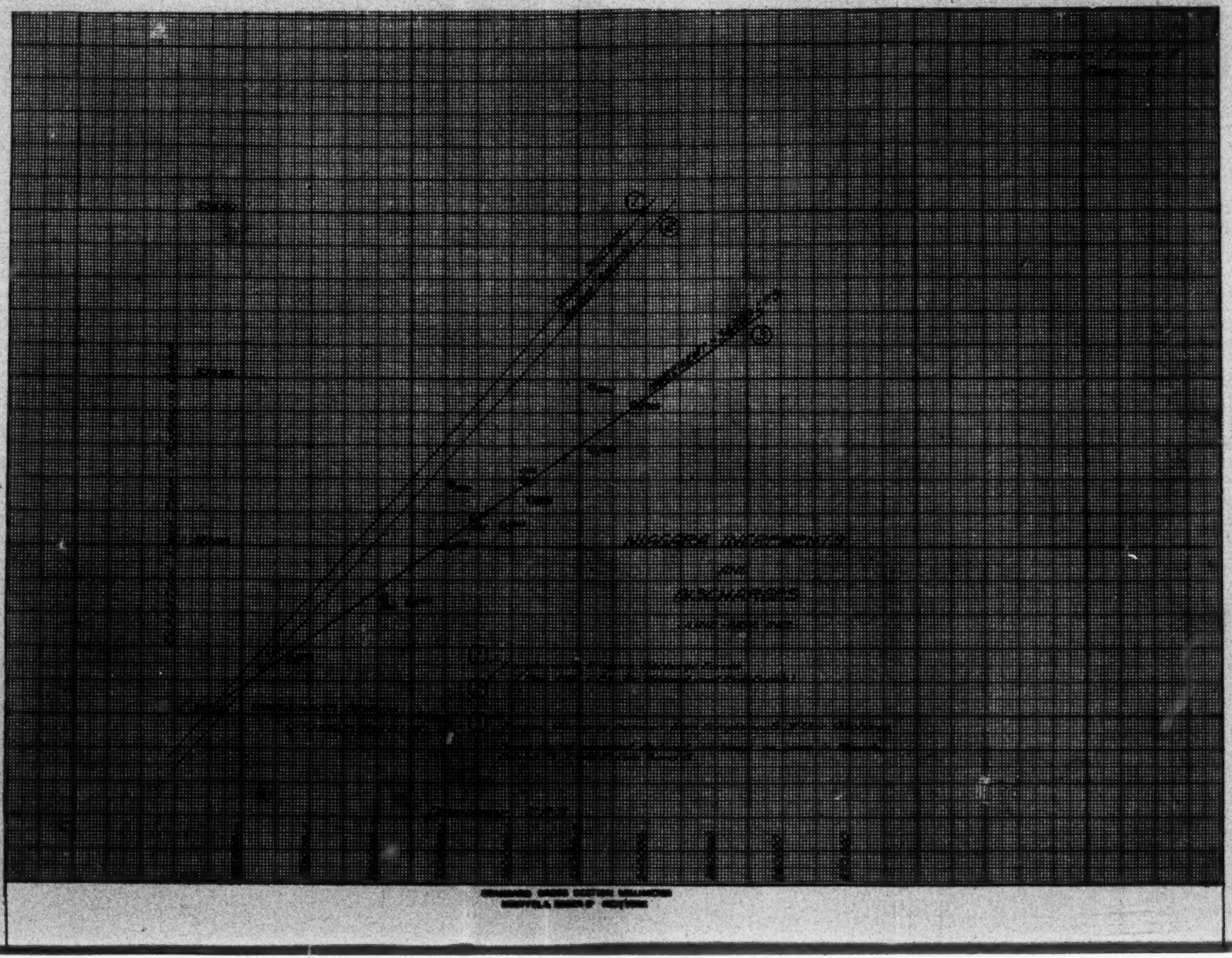
Comparisons of Discharge
St. Lawrence & St. Clair
June - Nov. Incl.

1	2	3	4	5	6	7
Period	Saint Lawrence Defendants Equation c.f.s.	Ontario Supply Old Storage c.f.s.	Erie St. Clair Supply Old Storage c.f.s.	Reduced St. Clair c.f.s.	St. Clair Defendants Equation c.f.s.	Col. 6 less Col. 5 c.f.s.
1883 } 1888 }	287700	-20290	-22630	236800	264700	27900
1889 } 1891 }	266100	-41480	-25700	198900	213300	14400
1892 } 1903 }	236400	-28580	-23500	184300	194400	10100









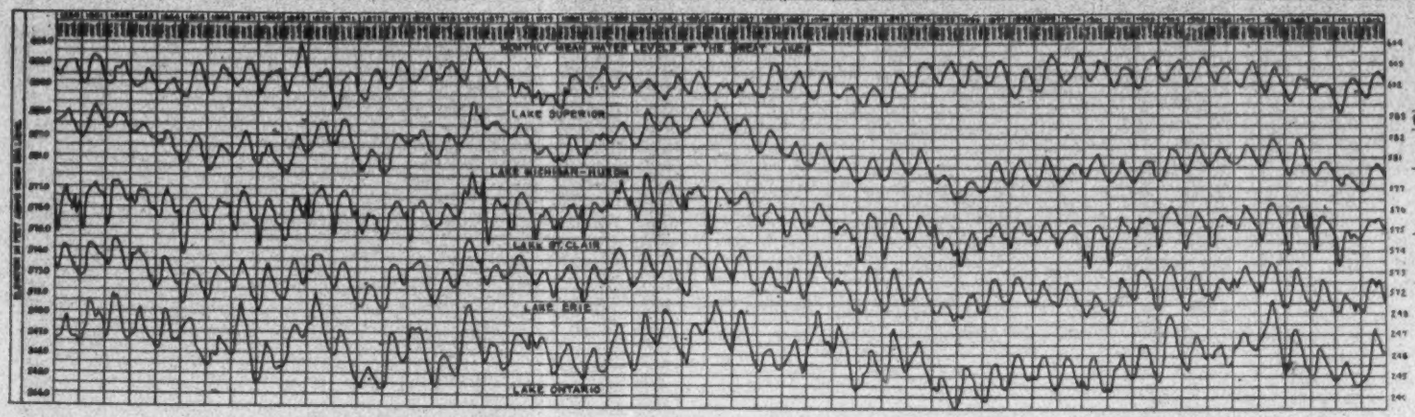
Chicago Sanitary District Stearns' Exhibit #3
Comparison of Discharges
Niagara River
June - Nov. 1883-1906

*St. Lawrence Discharge based on 1912 Discharge Curves prepared by Sherman Moore

1	2	3	4	5*	6	7
June to Nov. Year	Discharge* St Lawrence C.F.S.	Local Supply and Storage Chicago C.F.S.	Deduced Niagara C.F.S	Niagara Discharge Complaint Location C.F.S.	Col. 4 Minus Col. 3 C.F.S.	Buffalo Gage I.W.W. Comm. Ft.
1883	286500	18800	267700	238500	29200	573.80
4	284500	32000	252500	231600	20900	3.49
5	284000	19700	264300	240000	24300	3.87
6	289000	38600	249400	232900	16500	3.55
7	278800	34800	244000	230000	13400	3.44
8	248900	26000	222900	217800	5100	2.86
9	253500	37800	215700	211700	4000	2.58
1890	284200	41400	242800	225900	16900	3.23
1	244600	45300	199300	201600	- 2300	2.12
2	247500	23400	224100	217200	6900	2.83
3	261200	37400	223800	212100	11700	2.60
4	246500	34100	212400	207800	4600	2.40
5	203200	25900	177300	184100	- 4800	1.32
6	217500	29900	187600	192300	- 4700	1.69
7	226900	23500	203400	206100	2700	2.17
8	235000	26800	208200	209300	1100	2.28
9	231200	24400	206800	199000	7800	2.00
1900	232300	29500	203000	201700	1300	2.12
1	230800	31200	199300	191600	7700	1.66
2	241200	22800	218400	207300	11100	2.38
3	252700	32100	220600	211700	8900	2.58
4	272500	31300	241200	220000	21200	2.96
5	255700	22500	233200	217600	15600	2.85
6	241700	25000	216900	208800	8100	2.40

* Column 5 includes 2100 C.F.S. diversion thru Erie and Welland Canals.

FREEMANS EX. 1

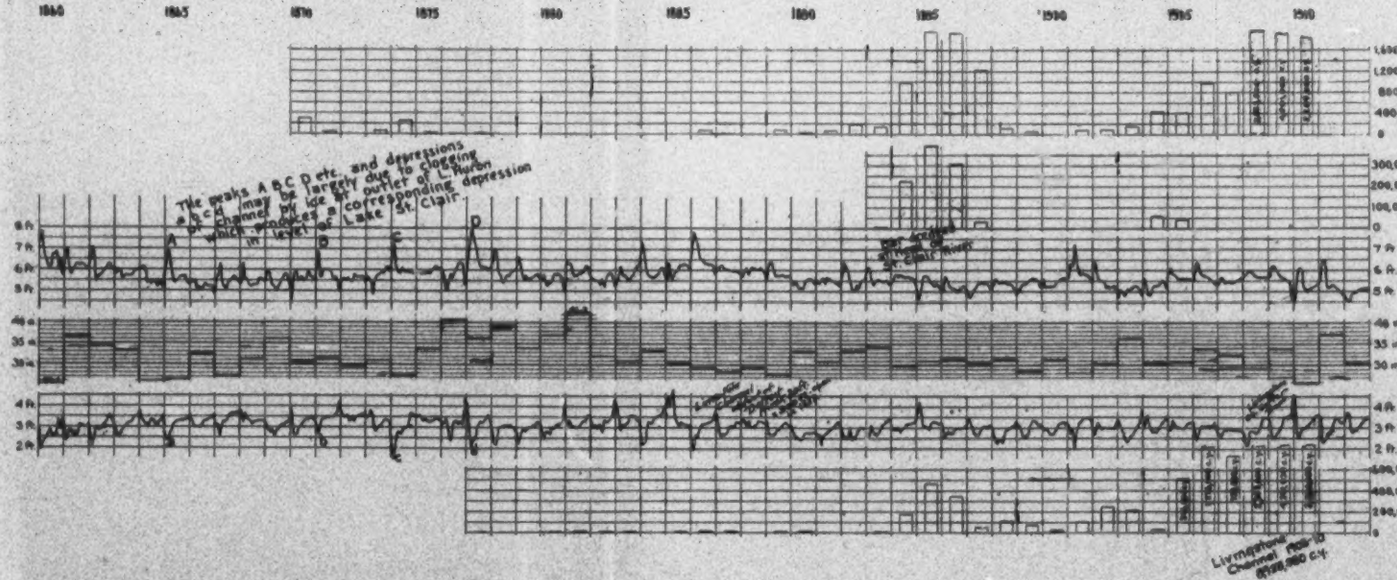


Computed effect of Diversion by Drainage Canal, in lowering lakes. Based on Defendants reductions of Complainants observations: Lowering of lakes regardless of any compensation works

For Diversion of	4000 c.f.s.	10000 c.f.s.	14000 c.f.s.
Huron	0.14 ft.	0.35 ft.	0.49 ft.
Erie		0.30 ft.	0.42 ft.
Ontario		0.33 ft.	0.46 ft.

LAKE LEVELS

1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910

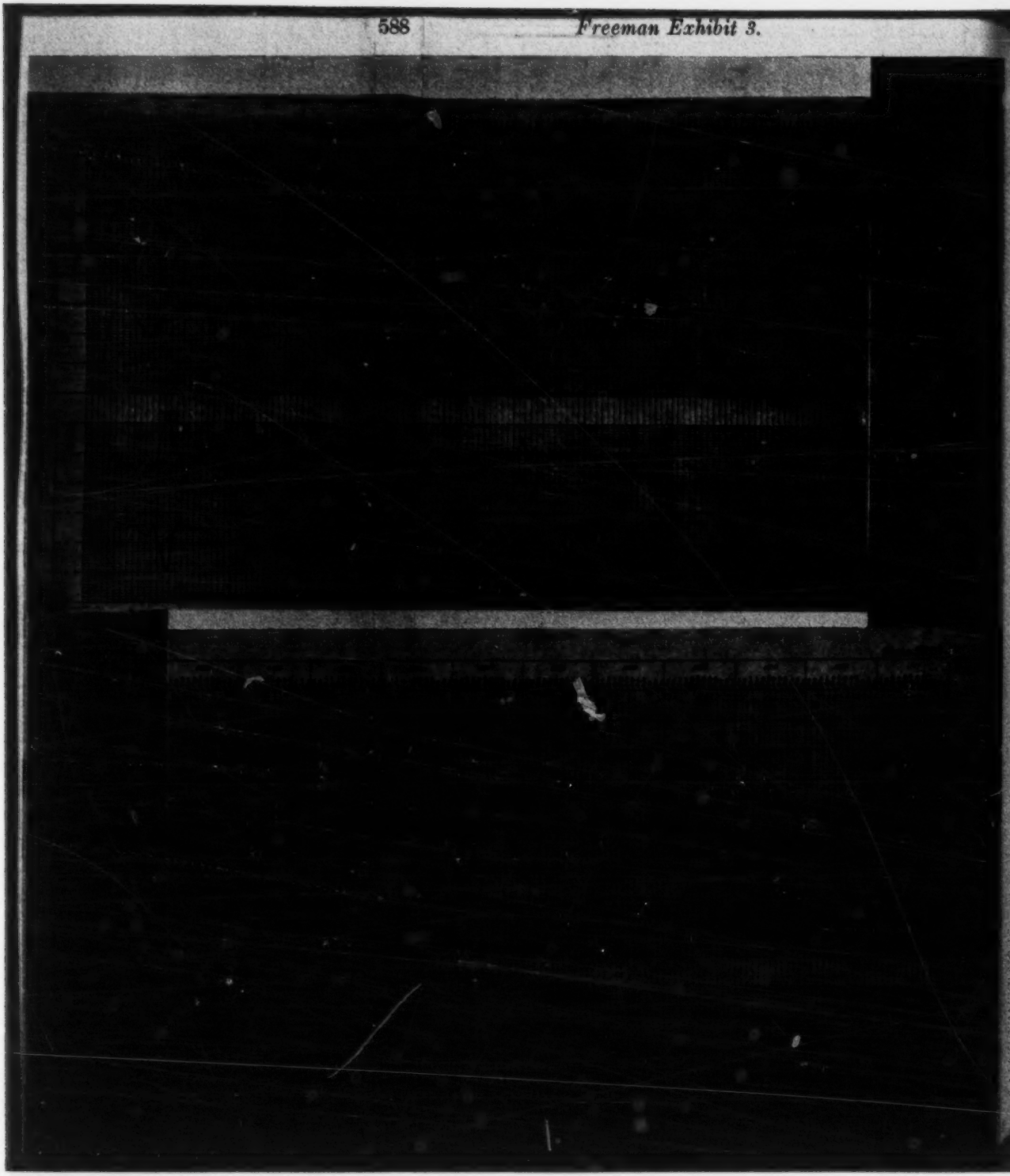


Studies Relative to

CHICAGO DRAINAGE CANAL

John R. Freeman, C.E.
Providence, R.I.

Mar. 17, 1910.



FREEMAN EXHIBIT 4.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

Paper No. 1259.

CHARACTERISTICS OF CUP AND SCREW CURRENT METERS; PERFORMANCE OF THESE METERS IN TAIL-RACES AND LARGE MOUNTAIN STREAMS; STATISTICAL SYNTHESIS OF DISCHARGE CURVES.*

BY B. F. GROAT, ASSOC. M. AM. SOC. C. E.

WITH DISCUSSION BY MESSRS. W. G. PRICE, E. E. HASKELL, CHARLES H. MILLER, JOHN C. HOYT, C. W. STANIFORD, AND B. F. GROAT.

During the summer and autumn of 1911 the writer ran a number of efficiency tests on two of the 6,000-h. p. hydraulic turbine units recently installed in the power-house of the St. Lawrence River Power Company, at Massena, N. Y. On one of the units, two sets of tests were run, one prior, and one subsequent, to cutting off several feet of the draft-tubes. On the other unit, one set of tests was run after the draft-tubes had been shortened, as had been done in the case of the other turbine unit.

In all, about 40,000 instrumental readings, including gauge readings, were made. Of these, 7,000 were complete velocity observations by current meters, and 4,000 additional readings on a Pitot tube furnished about 100 complete velocity observations for comparison with simultaneous readings by the current meters.

Owing to the nature of the tail-races, which discharge into the Grasse River, a weir test was out of the question. Before beginning the tests, therefore, it became necessary to decide between the current meter and Pitot tube as instruments for measuring the flow.

*Presented at the meeting of February 5th, 1913.

In favor of the current meter is its simplicity and the f
cility with which it may be used in tail-races. Against it
the fact that, notwithstanding the large number of observe
who have experimented with it and the large number of re
ords which have been made by it, there is still a great deal
well-founded skeptical discussion as to the accuracy of t
instrument when the records are based solely on the sti
water rating.

The Pitot tube has been not only a subject of adverse cr
cism but also an instrument about which much positive i
norance seems to exist. It would seem, however, that t
recent demonstrations of the accuracy of Darcy and Basi
experiments, 1865, by Messrs. William Monroe White,* F
F. Moody, Gardner S. Williams, John R. Freeman, and other
should sufficiently dispel all doubts as to the reliability
the instrument. On the other hand, where the velocity of t
water is variable from moment to moment, a large number
readings must be taken and reduced to a mean square roo
in order to obtain sufficiently close approximations to th
average in any one velocity determination.

After a final summary of advantages and disadvantage
it was decided to use both the screw and cup types of curre
meter, and to check their records, if necessary, with a Pit
tube.

E. E. Haskell, M. Am. Soc. C. E., Director of the College o
Civil Engineering Cornell University, made up one of h
screw type meters especially for the series of tests to be u
dertaken, and a new Gurley-Price meter of the cup type (No
600) was purchased from the makers at Troy. Master Me
chanic D. J. Jones, of the Power Company, made up a Pito
tube, following as nearly as possible the description of Tub
N given in Mr. White's paper, mentioned above.

The following are the general conclusions concerning cu
rent meters which have been drawn from the tests with th
foregoing equipment:

1.—†When a cup meter is run in perturbed water it wi
register a larger number of revolutions per second than
perfect still-water rating would indicate.

2.—†When a screw meter is run in pertubed water it wi
register a smaller number of revolutions per second than
perfect still-water rating would indicate.

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*"The Pitot Tube: Its Formula," by William Monroe White, *Jour*
Association of Engineering Societies, Vol. XXVII, 1901, p. 35.

For other reference marks see following page.

3.—†In the foregoing sense, a cup meter is affected relatively to a much greater extent than a screw meter. In the tail-races at Massena, as an average, the cup meter was affected to the extent of 6%, while the Haskell meter was affected mostly by less than 1 per cent. In boilers of considerable violence the cup meter may easily over-register by 25%, while the screw meter will under-register by not more than 3 or 4 per cent.

4.—Either type of meter when run in perturbed water will give uniform records in equal times, provided these times are sufficiently long, the flow of the water itself being subject to an established regimen.

5.—If both types of meter are used simultaneously in perturbed water, the disparity between the discrepant velocities thus determined by the still-water rating may be taken as a basis for correcting the discrepant velocities.

6.—The average corrections thus obtained for the Haskell meter when run with the Gurley-Price meter in the tail-races at Massena varied from 0.5 to 0.9 of 1%, while the corresponding corrections for the Gurley-Price meter were about six times larger. Comparisons with the Pitot tube furnished substantially the same corrections as those obtained by comparison of the meters.

7.—It would seem to follow that current-meter observations based on still-water ratings without further correction should

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†In a discussion of a paper on current meter and weir discharge comparisons by Edward C. Murphy, Assoc. M. Am. Soc. C. E. *Transactions*, Am. Soc. C. E., Vol. XLVII, 1902, p. 370, Charles H. Miller, M. Am. Soc. C. E., describes certain experiments on screw and cup meters in the following language:

"The Haskell meter was lowered from one side of the skiff and one of the Price meters from the other side, both to the same depth (about 5 ft.). The registrations or revolutions of each, for periods of from 5 to 10 minutes, were noted; then, for similar periods of time, the skiff was caused to rock from one side to the other at short intervals, and the registrations recorded, the movement of the skiff giving to the meters a vertical motion of from 1 to 2 ft. Under this motion the revolutions of the Price meter increased, while those of the Haskell meter decreased, but in a less proportion than the increase of the Price meter, showing that the error due to instability of support is greater in the Price than in the Haskell meter. Lack of time prevented more extended observations, and in different velocities of current, which probably would have evolved some fixed difference due to the different construction of the meters in question."

Conclusions 1, 2 and 3, of the present paper seem to have been fairly stated by Mr. Miller, but as applied only to instability of support. They are here advanced as inherent characteristics of these different types of meter, and extended to apply, not only to cases of instability of support, but also to these current meters generally, however supported, in flowing water.

be made with great caution. On the other hand, it seems certain that the correction for a cup meter when run at a good meter station on an open river is not large, while the corresponding correction for a screw meter may be negligible.

Plate XXIII shows the results of a number of ratings of the Haskell meter. The general method was similar to that adopted by the United States Lake Survey, as described in the reports by F. C. Shenehon, M. Am. Soc. C. E.,* covering his current-meter observations. The meter was suspended either by cable or rod from a bowsprit at the head of a light skiff. The skiff, with an observer, was then towed back and forth over a 200-ft. base at a given velocity, one such double run constituting a velocity observation. The total time and total number of revolutions then stand for the transit of a 400-ft. base in perfectly still water.

The first four ratings, on June 29th and 30th, 1911, were made along the longitudinal center line of Lock No. 15 in the old Cornwall Canal, at Cornwall, Ont. Both lock gates were open, but the north miter leaf of the lower gate, opening into the St. Lawrence River was not fully into its recess in the north wall. The meter was about 4 ft. below the surface of the water, and the depth in the lock was 9 or 10 ft. The water in the lock had a tendency to surge at times. Sometimes there was considerable velocity through the lock, and at other times very little.

The ratings of August 12th and October 3d, 1911, were made in a bay of the Grasse River, opposite the power-house of the St. Lawrence River Power Company, at Massena, N. Y. The meter was about 2.25 ft. below the surface of the water, and the average depth under the base line was about 7 ft., with a shallow spot near the east end about 5 ft. deep. There was very little current, but at times there were surges due to the operation of the power-house just across the river.

The ratings of July, 1912, were made under the direction of Professor Arthur M. Greene, Jr., at the rating station of Rensselaer Polytechnic Institute, Troy, N. Y., after the meter had been used extensively at Massena and in North Carolina and Tennessee. The meter had been overhauled twice at Cornell University before these ratings, but long after those at Massena. The meter was also provided with a new shaft. After running a complete set of tests at Troy, the new shaft was put in and another set of tests was made.

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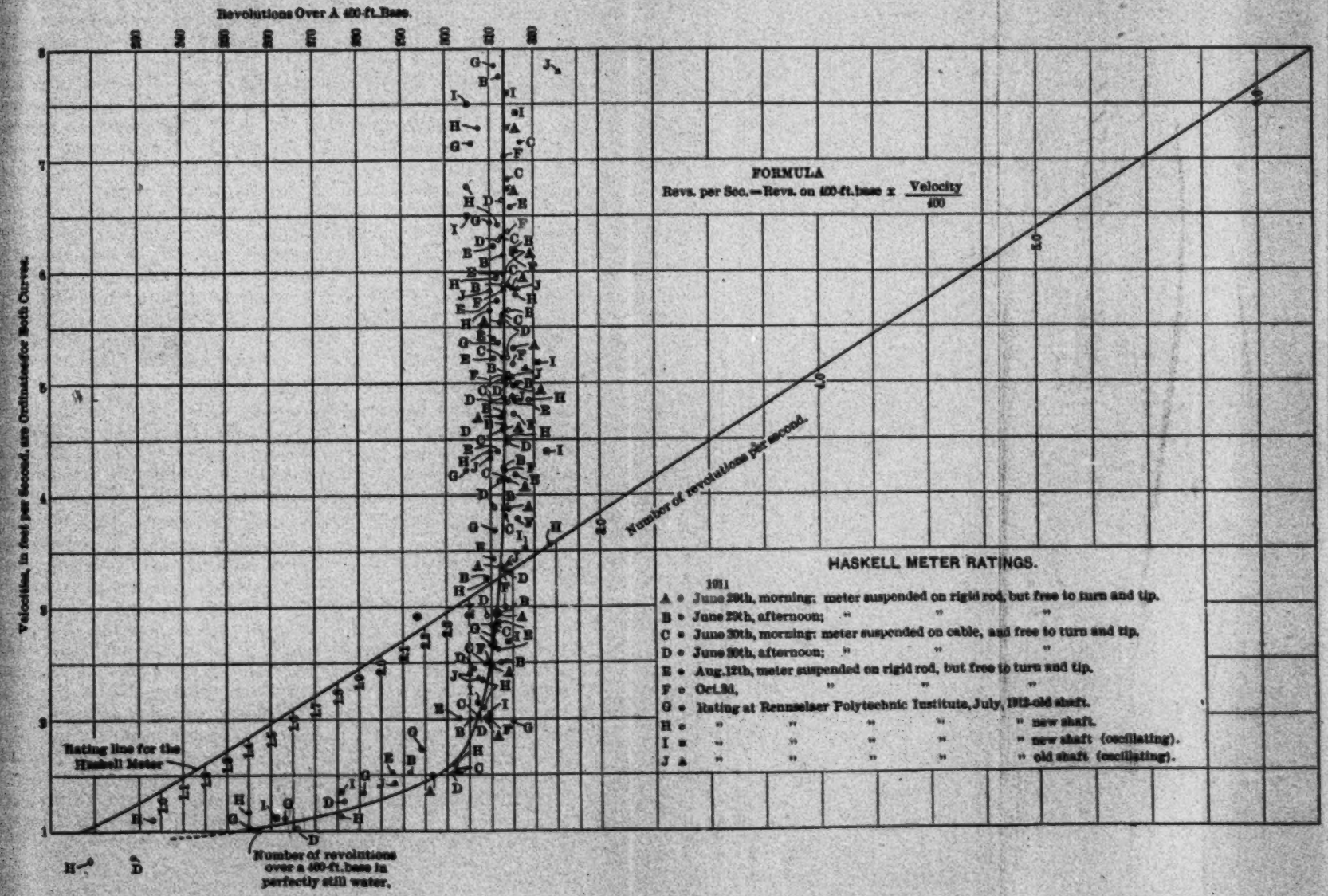
*As described in Reports, Chief of Engineers, U. S. Army, 1900 to 1904, inclusive.

PLATE XXIII.
TRANS. AM. SOC. CIV. ENGRS.
VOL. LXXVI, No. 1289.
GROAT ON
CUP AND SCREW CURRENT METERS.



The curve of revolutions over a 400-ft. base was plotted from the first four ratings in the Cornwall Canal. It will be seen from Plate XXIII, however, that the subsequent ratings do not materially alter the position of this line, up to velocities of 5 or 6 ft. per sec. If the correction were made, the number of revolutions, as shown by the line, would be increased only ¼% at 4 ft. per sec., and reduced only ¼% at about 8 ft. per sec. In fact, it may be seen that, out of about 100 double runs in the canal lock and Grasse River, not one plotted point differs by more than 1% from the line of revolutions as determined from the first four ratings for velocities of more than 1½ ft. per sec. For velocities of less than 1½ ft. per sec. the line of revolutions is so steep that errors of somewhat larger magnitude are to be expected. In the oscillating tests, the meter was oscillated parallel to the motion of the car, and covered an amplitude of 5¾ in. for every 8-ft. advance of the car. Transverse oscillations reduce the number of revolutions over a given base. The relations between velocity and revolutions over a 400-ft. base were then plotted, as shown on Plate XXIII, and from the resulting curve the rating line for still water was located and drawn, also as shown on that plate.

After having drawn the rate line, a reduction diagram, Plate XXIV, may be prepared, from which velocities may be read directly when referred to time and revolutions. This obviates either the necessity for reducing revolutions to revolutions per second, or of taking a fixed time for observing velocities, which is inexpedient where velocities are variant.

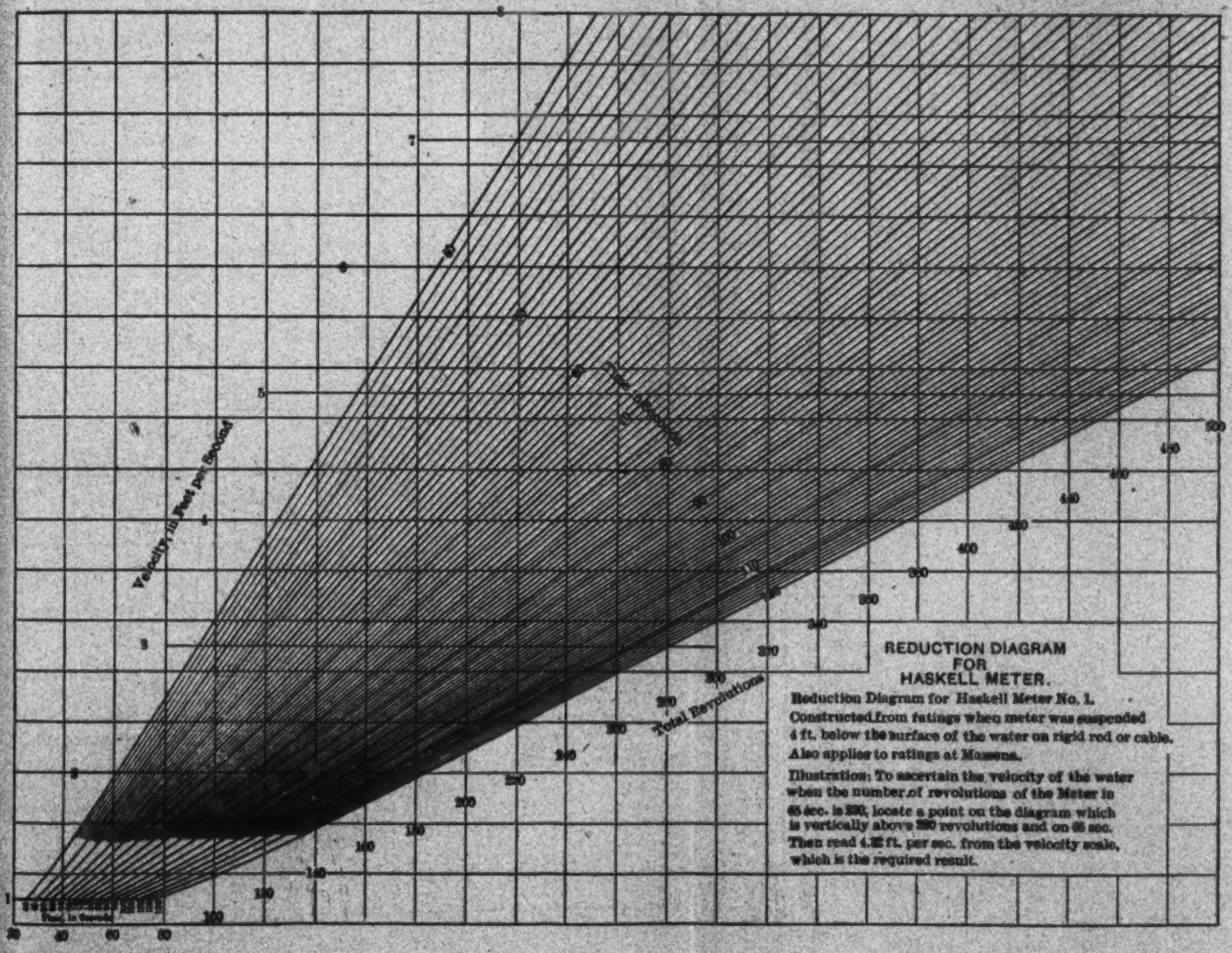
Plate XXV shows the Gurley-Price meter rating curves, obtained in a manner precisely similar to that used for the Haskell meter. In fact, the ratings were frequently made on the same day as for the Haskell meter.

In order that there may be no misundertanding concerning these ratings, it may be stated that the tests were severe, when considered as a whole. Some of the ratings were made at a depth of 4 ft., some at a depth of 2 ft. 3 in., some in windy weather, some in calm weather, and several different observers acted at different times.

Under all these diverse conditions, it may be seen that the Haskell meter, in the Massena and Cornwall ratings, never varied by more than 1% in any individual observation, and that rating lines drawn for different ratings would differ by only 0.2 or 0.3 of 1% at the greatest.

The Gurley-Price meter exhibits a much greater range of

PLATE XXIV.
TRANS. AM. SOC. CIV. ENGRS.
VOL. LXXVI, No. 1255.
GROAT ON
CUP AND SCREW CURRENT METERS.

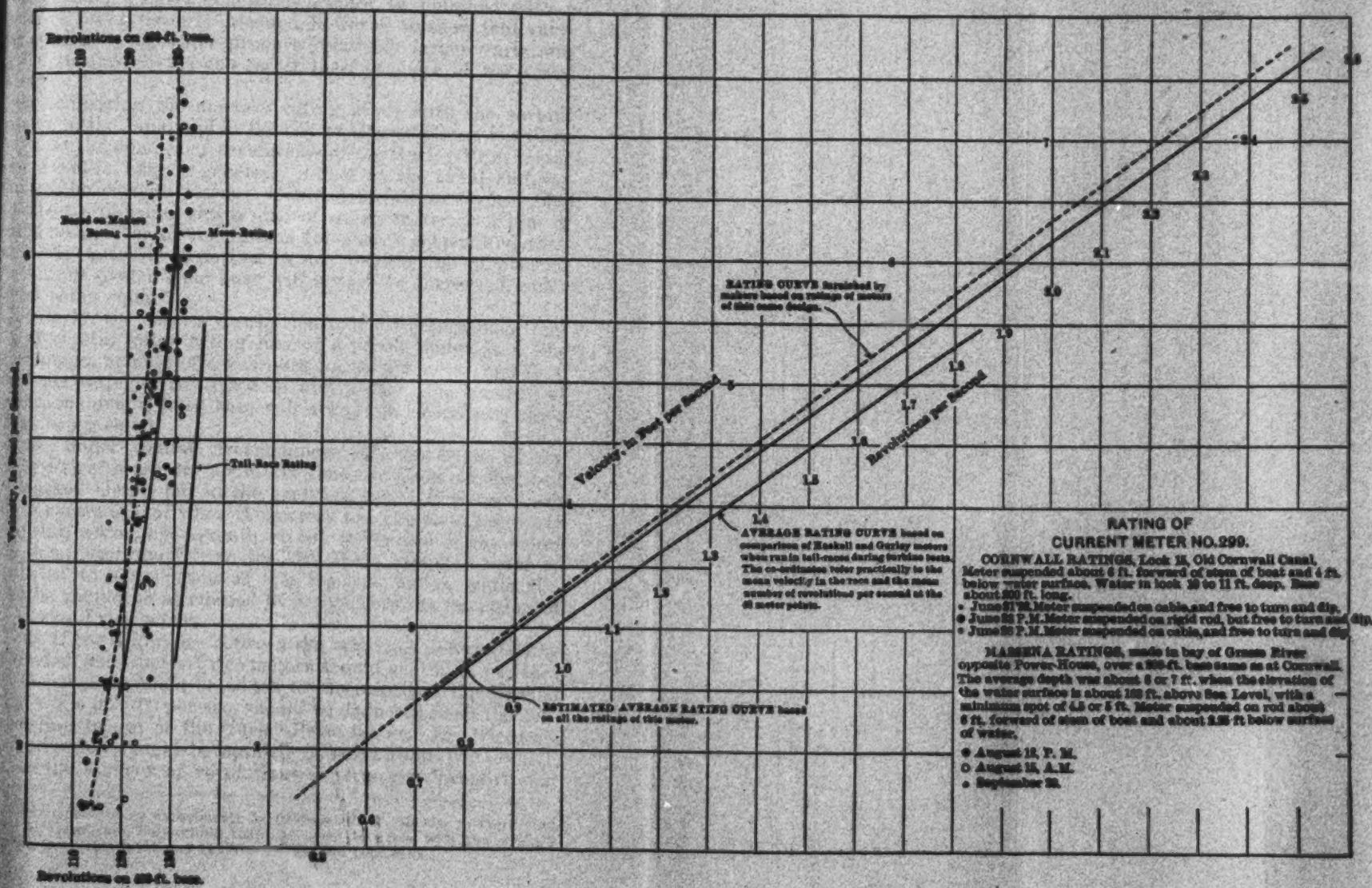


REDUCTION DIAGRAM FOR HASKELL METER.

Reduction Diagram for Haskell Meter No. 1.
Constructed from ratings when meter was suspended 4 ft. below the surface of the water on rigid rod or cable.
Also applies to ratings at Massena.

Illustration: To ascertain the velocity of the water when the number of revolutions of the Meter is 65 sec. is 230, locate a point on the diagram which is vertically above 230 revolutions and on 65 sec. Then read 4.32 ft. per sec. from the velocity scale, which is the required result.

PLATE XXV.
TRANS. AM. SOC. CIV. ENGRS.
VOL. LXXVI, No. 1259.
GROAT ON
CUP AND SCREW CURRENT METERS.



RATING OF CURRENT METER NO. 299.

CORNWALL RATINGS, Lock 18, Old Cornwall Canal. Meter suspended about 6 ft. forward of stem of boat and 4 ft. below water surface. Water in lock 10 to 11 ft. deep. Base about 200 ft. long.

- June 21 P.M. Meter suspended on cable, and free to turn and dip.
- June 22 P.M. Meter suspended on rigid rod, but free to turn and dip.
- June 23 P.M. Meter suspended on cable, and free to turn and dip.

MASSENA RATINGS, made in bay of Grasse River opposite Power-House, over a 500-ft. base same as at Cornwall. The average depth was about 6 or 7 ft., when the elevation of the water surface is about 192 ft. above Sea Level, with a minimum spot of 4.5 or 5 ft. Meter suspended on rod about 6 ft. forward of stem of boat and about 2.25 ft. below surface of water.

- August 12, P. M.
- August 15, A.M.
- September 20.

variations, 5 or 6% up to velocities of 5 ft. per sec., which were considerably in excess of the mean velocities in the tail-races where the meter was used.

It is not contended here that a satisfactory still-water rating under perfect conditions cannot be obtained with a meter of this type; it is intended, however, to show that varying conditions of water produce relatively larger variations in the records of the cup meter than in those of the screw meter.

On comparing the maker's rating curve with the several ratings in the canal and in the bay of Grasse River, it will be seen that the number of revolutions of the Gurley-Price meter over a 400-ft. base is generally higher in the canal and bay than in the maker's rating. Hence it is fair to suspect that a perfect still-water rating line of a cup meter is a line of minimum number of revolutions for such a meter, and that, when the water is disturbed in any degree, the number of revolutions over a fixed base will always be increased, other things being equal.*

Similarly, the contrary suspicion may be entertained, that a perfect still-water rating line of a screw meter is a line of maximum number of revolutions for such a meter, and that, when the water is disturbed in any degree, the number of revolutions over a fixed base will always be decreased, other things being equal.

Since, under similar circumstances, the deviations of the Gurley-Price meter are about six times as large as those of the Haskell meter, but in the contrary sense, it would seem fair to conclude that when the meters are run simultaneously in flowing water, one-seventh of any difference in the velocities thus determined from the still-water ratings should be attributed to a deviation of the Haskell meter, while six-sevenths should be attributed to a simultaneous deviation of the Gurley-Price meter.

Thus, if the difference between the velocities determined by the Haskell and Gurley-Price meters should be 0.42 ft. per sec., 0.06 ft. per sec. should be added to the record of the Haskell meter, while 0.36 ft. per sec. should be deducted from the corresponding record of the Gurley-Price meter. In strictness, this correction should be applied to revolutions per second, but, as the number of revolutions is so nearly proportional

*Certain interesting experiments by Professor L. F. Moody, in the rating station at Rensselaer Polytechnic Institute, seem to agree with the writer's experiments on this point and confirm the general conclusion.

to the velocity, and as the corrections are relatively small, no serious error results. The particular ratio here determined, of course, applies only to the two individual meters as used in the tail-races at Massena by the writer.

In order to establish more satisfactorily the principle mentioned above, the boat was rocked during several of the runs of a rating, imparting to the meter which was being rated an oscillation in an arc about 3 ft. long and about 2½ ft. in radius, and at right angles to the direction in which the meter was being drawn through the water. The result was that the Gurley meter was found to increase its number of revolutions by 15% while the Haskell meter reduced its number of revolutions by 2½%, practically the same ratio as that deduced above from the rating curves. The effect of longitudinal oscillations was tested also. The result of special tests of this character at Rensselaer Polytechnic Institute may be seen on Plate XXIII. Subsequently, other tests on a new Haskell meter showed that longitudinal oscillations of 22 in. in 6 ft. advance of car retarded the meter slightly, up to velocities of about 2 ft. per sec., above which the meter was accelerated, the error being less than 2% at 9 ft. per sec. The net result in perturbed water, however, seems to be slight retardation in all cases.

It is now desirable to show how these principles have been used to correct the current-meter records actually observed in the tail-races during the turbines tests referred to at the outset. In order to do this properly, it will be necessary to state another conclusion, based on the current-meter records, which the writer hopes to take up more fully in the future under another title. The conclusion is as follows:

Under an established regimen, the distribution of the flow of water in a tail-race obstructed by tilling racks is fixed in character, the ratio of the average velocity at any given point to that at any other given point in the race being constant. This proposition applies over a considerable range in the total amount of discharge, but supposes the actual wetted cross-section of the race to remain the same.

The foregoing proposition was proven from a number of the turbine tests by computing and compiling the relative velocities at the 84 meter points in the races where velocity observations were taken. A turbine unit discharged through two tail-races, each about 15 ft. wide, while the depth of the water varied from 15 to 16 ft. The meter section of each race was divided into six equal vertical, and seven equal horizontal

strips, and the meter points were the forty-two intersections of the median lines of the strips. The verticals were numbered 1 to 6 from west to east, while the depths were numbered 1 to 7 downward.

To demonstrate the truth of the principle of a fixed distribution of flow in tail-races, and also as a verification of Conclusion No. 4, Tables 1 to 4 are given:

TABLE 1—GURLEY-PRICE METER IN WEST RACE, SHOWING CONSTANCY OF VELOCITIES TAKEN IN QUICK SUCCESSION. VELOCITIES WERE OBSERVED WITH A SINGLE STOP-WATCH PROVIDED WITH TWO SECOND HANDS.

Test of September 9th, at 0.82 gate.
The numbers are of revolutions per second.

Depths.	Verticals.						Totals of lower set.
	1	2	3	4	5	6	
1	1.38	1.40	1.15	0.88	0.90	0.94	6.69
	1.36	1.43	1.16	0.89	0.87	0.95	
2	1.39	1.44	1.40	1.26	1.20	1.16	7.70
	1.34	1.44	1.40	1.24	1.22	1.16	
3	1.36	1.44	1.42	1.40	1.34	1.31	8.46
	1.36	1.44	1.39	1.41	1.35	1.31	
4	1.37	1.44	1.43	1.39	1.31	1.27	8.41
	1.36	1.44	1.43	1.39	1.32	1.26	
5	1.38	1.47	1.38	1.40	1.35	1.28	8.57
	1.40	1.46	1.38	1.40	1.37	1.28	
6	1.70	1.78	1.80	1.77	1.61	1.06	10.09
	1.66	1.78	1.80	1.78	1.60	1.06	
7	1.60	1.81	1.84	1.78	1.78	1.06	10.84
	1.66	1.80	1.84	1.78	1.79	1.06	
Totals of lower set.	10.07	10.74	10.75	9.76	9.58	9.64	60.56

The register was started first and the observer noted the pointer as it clicked from revolution to revolution of the meter. By synchronizing with the rythm of the register, it was possible for the observer to start the stop-watch almost exactly at the moment the register clicked to zero. Similarly, the primary second hand could be stopped after any desired number of revolutions while the secondary hand could be stopped at, say, twice that number. Thus, two or more velocities in immediate succession could be determined for each meter point in the tail-races.

In support of the principle of fixed distribution, it may be stated that the percentages corresponding to the figures of

Tables 1 and 2 at the 84 meter points agree remarkably well with the corresponding ones of Tables 3 and 4 after applying certain necessary small corrections. Tables 1 and 2 each represent an individual set of double discharge measurements in one of the races, while Tables 3 and 4 have been compiled as average percentages from a number of such sets of observations.

In Verification of Conclusion No. 4, it may be seen that each pair of velocities determined at the same point by either meter consists practically of two equal velocities. This truth has been found to apply throughout the turbine tests.

TABLE 2.—HASKELL METER IN EAST RACE, SHOWING CONSTANCY OF VELOCITIES TAKEN IN QUICK SUCCESSION. THE COMPARISONS ARE NOT AS GOOD AS WITH THE GURLEY-PRICE METER, BECAUSE THE VELOCITIES WERE TAKEN WITH TWO DIFFERENT WATCHES, ONE OF WHICH WAS NOT VERY RELIABLE.

Test of September 9th, at 0.82 gate.
The numbers are of feet per second.

Depths.	Verticals.						Totals of lower set.
	1	2	3	4	5	6	
1.....	3.75	3.74	3.68	3.61	3.94	3.75	
	3.73	3.75	3.80	3.80	3.97	3.73	17.40
2.....	3.68	....	....	....	....	....	
	3.67	3.69	3.86	3.97	3.76	4.01	21.40
3.....	4.13	3.96	3.92	3.91	4.13	4.09	
	4.08	3.99	3.78	3.98	4.17	4.10	24.34
4.....	4.21	3.98	3.94	3.77	3.98	4.07	
	4.03	3.95	3.94	3.70	3.91	4.05	23.45
5.....	4.09	3.90	3.73	3.68	3.91	4.03	
	4.05	3.94	3.73	3.67	3.94	4.20	23.27
6.....	4.17	4.00	3.74	3.61	4.13	4.44	
	4.30	4.01	3.73	3.68	4.13	4.49	24.35
7.....	3.97	3.97	3.86	3.85	4.06	4.01	
	3.93	3.97	3.86	3.91	4.06	4.01	23.37
Totals of lower set.	23.51	23.89	23.56	23.46	23.99	23.92	142.33

The two velocities at each meter point were taken in immediate succession in a manner similar to that described in the foot-note under Table 1, except that two stop-watches were used. The observations were about 1 min. in duration for the first velocity and twice as long for the second velocity.

TABLE 3.—RELATIVE DISTRIBUTION OF FLOW IN WEST RACE OF UNIT NO. 3 DURING TESTS OF JULY AND AUGUST. WATER SURFACE AT ELEVATION 162.85.

Depths.	Verticals.						Totals.
	1	2	3	4	5	6	
1	2.16	2.16	1.84	1.88	1.80	1.97	11.10
2	2.11	2.41	2.32	2.07	2.02	2.22	13.15
3	2.04	2.37	2.46	2.21	2.15	2.14	13.30
4	2.13	2.30	2.34	2.20	2.05	2.36	13.53
5	2.19	2.41	2.37	2.20	2.27	2.07	14.40
6	2.05	2.37	2.00	2.05	2.42	2.05	16.47
7	2.72	2.37	2.00	2.00	2.00	2.00	17.70
Totals	16.00	17.40	17.53	16.21	15.66	17.06	99.96

The numbers are percentages of the sum of the velocities at the 42 meter points in the race. Thus, in Vertical 1, Depth 1, the velocity is 2.16% of the sum of all the velocities at the meter points.

TABLE 4.—RELATIVE DISTRIBUTION OF FLOW IN EAST RACE OF UNIT NO. 3 DURING TESTS OF JULY AND AUGUST. WATER SURFACE AT ELEVATION 162.85.

Depths.	Verticals.						Totals.
	1	2	3	4	5	6	
1	1.72	1.80	1.86	1.65	2.16	2.24	11.20
2	2.08	2.24	2.00	2.16	2.24	2.24	12.70
3	2.48	2.51	2.19	2.20	2.51	2.20	13.70
4	2.60	2.24	2.36	2.12	2.17	2.41	14.30
5	2.36	2.41	2.15	2.10	2.12	2.46	13.80
6	2.72	2.40	2.40	2.02	2.40	2.72	15.80
7	3.00	2.24	2.11	2.00	2.00	2.72	16.60
Totals	17.12	16.88	16.91	16.25	16.97	17.22	100.00

The percentages of Tables 3 and 4 are computed by dividing the velocity at any meter point by the sum of the velocities at all the meter points.

Attention should be directed to the fact that while water discharged from a turbine will be much quieted by stilling racks, yet the latter themselves are sources of disturbance, and that the violent agitation caused by the turbines is merely supplanted by an entirely different type of disturbance produced by the racks. The effect of the racks is to render the flow parallel to the side-walls of the race, but the body of the water is full of small eddies and boilers of more or less violence. The parallelism of flow at each meter point was tested by a kind of inverted weather vane, which the writer understands was first used by John R. Freeman, M. Am. Soc. C. E. The indications of parallelism of flow by this vane were extremely satisfactory at all points.

The meter section was about 30 ft. down stream from the racks. The effect of the disturbance from the racks, however, was plainly indicated by the divergence of the velocity records, based on the still-water ratings, when the two meters were run in quick succession at any meter point. It is well to note here that the velocity was greater near the bottom of the race than at the top, and that the agitation by the racks was greater near the top than at the bottom, where the flow was extremely steady and subject to little or no agitation. This is clearly shown by the records, and especially by the fact that the clicking of the register was almost absolutely uniform when the meters were near the bottom. It is also shown by the fact that there was always a greater disparity between the meter records near the surface than at the bottom.

To be precise, the corrections for the meters should be computed for each of the 84 meter points in the races. Practically, the corrections may be made for the average velocities in the seven horizontals, because the velocities along any horizontal do not vary widely.

An example of the computation of corrections for the Haskell and Gurley-Price meters is given in Table 5.

TABLE 5.—COMPUTATION OF VELOCITY CORRECTIONS.

Horizontal in which meter was run.	Velocities Based on the Still-Water Ratings.		Difference.	One seventh of difference + Haskell = true velocity.	Velocity excessive by Gurley. Percentage.	Velocity deficient by Haskell. Percentage.
	Gurley.	Haskell.				
1.....	3.04	3.26	0.22	3.04	14.5	2.4
2.....	4.40	4.50	0.10	4.50	12.0	2.0
3.....	4.74	4.44	0.30	4.46	5.8	0.96
4.....	4.66	4.62	0.04	4.66	4.3	0.72
5.....	5.08	4.89	0.19	4.98	3.1	0.55
6.....	5.09	5.35	0.13	5.37	2.0	0.34
7.....	6.29	6.75	0.17	6.17	2.3	0.39
Totals..	33.07	33.91	2.16	33.21		

$$\text{Average error of Gurley meter} = \frac{6}{7} \times \frac{2.16}{33.21} = 5.6 \text{ per cent.}$$

$$\text{Average error of Haskell meter} = \frac{1}{7} \times \frac{2.16}{33.21} = 0.93 \text{ " "}$$

The method given in Table 5 for computing the corrections for the velocities is based solely on the current-meter ratings and the rocking experiments in conjunction with the fundamental propositions before stated. It is desirable, therefore, to have independent means of checking the methods and the numerical results.

Accordingly, a Pitot tube was operated at the meter points, in Depths 2, 3, 5, 6, and 7, simultaneously with the Haskell meter. While the meter was recording in Vertical 3 the Pitot was recording in Vertical 2. After the record was taken, both the meter and Pitot were advanced to the next succeeding verticals, so that the meter would then record in Vertical 4 while the Pitot was in Vertical 3. Depths 1 and 4 were omitted because the tail of the Pitot was out of water in Depth 1, and the construction of the piping of the Pitot did not conform with the staging for the observers in such a way as to admit of readings in Depth 4. This might have been remedied, but no great importance was attached to these facts.

The results of these tests are given in Table 6.

It should be noticed in Table 6 that the velocities given in Verticals 1 and 6 were not taken in quick succession. The meter and tube were traversed across each horizontal, beginning with the Pitot tube in Vertical 1 and the meter in Vertical 2, and ending with the Pitot tube in Vertical 5 and the meter in Vertical 6. After the five horizontals were traversed in this manner, the Pitot tube and meter were interchanged in

relative position, and readings were taken at the five dept with the Pitot tube in Vertical 6 and the meter in Vertical All other readings by the meter or Pitot tube were follow immediately by a reading of the other instrument.

The writer does not wish to make too much of these Pi tube tests. The experimenters were not familiar with the i strument, as they had used it on only one other occasion. T dynamic and static columns were drawn up on a scale gra uated to single tenths and half tenths of a foot and the di ferences in head were merely estimated to the nearest hu dredths of a foot. This may seem crude, but when it is co sidered that the water columns are both vibrating, sometim violently, that twenty or thirty readings are taken for ea velocity, and that all percentage errors are nearly split two by the process of extracting the square root of the hea it will be seen that the method is probably as accurate as ne be for the purpose at hand. Indeed, the results seem to justi this conclusion.

Attention may be directed to three general facts shown the summary of Table 6. The ratios for the verticals increa toward the right in the west race. They increase toward t left in the east race. The ratios for the horizontals increa upward in both races. On the whole, the tendency is for th ratio of the Pitot velocity to the meter velocity to increase u ward, as it should, as it has been shown that the meter retarded toward the surface.

TABLE 6.—COMPARISONS BETWEEN VELOCITIES DETERMINED BY PITOT TUBE AND HASKELL METER AT VARIOUS POINTS IN THE TAIL-RACES OF UNIT NO. 5.

Depth.		Verticals.														Ratios.
		1		2		3		4		5		6		Totals.		
		Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	
2	A	....	....	4.03	4.06	3.94	3.99	3.76	3.78	3.80	3.85	....	....	15.59	14.47	1.072
	A	....	....	4.15	4.09	3.96	3.11	3.80	3.86	3.85	3.89	....	....	15.15	15.80	1.046
	A	....	....	3.72	3.84	3.58	3.48	4.10	3.80	4.40	4.40	....	....	16.21	14.97	1.083
	A	....	....	3.80	3.84	3.98	3.77	4.30	4.30	4.40	4.40	....	....	16.50	16.09	1.030
	A&C	2.66	2.69	3.84	3.84	3.80	3.80	3.60	3.81	3.92	3.17	1.66	1.77	15.30	15.30	1.001
		2.66	2.69	23.00	17.86	17.76	15.62	17.04	17.09	18.62	17.90	1.66	1.77	76.55	72.50	1.055
3	A	....	....	4.06	4.03	4.14	4.09	4.05	3.96	4.26	4.20	....	....	16.75	16.41	1.020
	A	....	....	4.06	4.19	4.11	4.19	4.15	4.16	4.40	4.36	....	....	17.01	16.46	1.033
	A	....	....	4.06	4.16	4.06	4.04	4.01	4.00	4.40	4.36	....	....	17.13	17.43	0.983
	A&C	2.66	2.71	4.84	4.81	4.62	4.43	4.40	4.36	4.46	4.46	....	....	17.80	17.43	0.981
		2.66	2.71	3.96	3.96	3.94	3.41	3.16	3.10	3.96	3.80	2.66	2.66	15.30	14.26	0.972
		2.66	2.71	19.06	19.19	19.26	19.40	19.06	19.06	20.02	19.86	2.66	2.66	80.00	81.96	1.001
5	A	....	....	5.26	5.41	4.97	4.97	4.27	4.41	4.26	4.26	....	....	19.50	18.81	0.964
	A	....	....	5.27	5.26	4.96	4.96	4.46	4.47	4.23	4.29	....	....	19.74	19.12	0.960
	A	....	....	4.91	4.13	4.62	4.60	4.06	4.10	4.46	4.44	....	....	18.75	18.07	1.006
	A&C	2.61	2.66	4.46	4.14	4.06	3.96	4.11	4.00	4.04	4.00	....	....	16.96	16.46	1.030
		2.61	2.66	3.91	3.90	3.46	3.33	3.61	3.64	3.94	3.46	2.16	2.14	15.11	15.06	0.986
		2.61	2.66	23.10	21.94	19.31	20.04	19.39	19.60	19.73	19.94	2.16	2.14	89.11	86.97	0.969
8	A	....	....	5.26	5.26	5.47	5.46	5.41	5.35	4.26	4.21	....	....	21.17	21.08	0.976
	A	....	....	5.26	5.07	5.47	5.70	5.26	5.26	4.26	4.26	....	....	21.41	21.95	0.976
	A&C	2.74	2.66	3.86	3.87	3.07	3.10	3.06	3.00	3.80	3.87	2.02	2.17	16.53	16.60	0.996
		2.74	2.66	19.38	19.26	14.01	14.26	13.73	14.06	12.48	12.34	2.02	2.17	80.11	80.17	0.999

REMARKS: *A*—tests in W. race at 0.7 gate; *B*—tests in E. race at 0.7 gate; *C*—tests in W. race at 0.37 gate.

TABLE 6.—(Continued.)

Depth.		1		2		3		4		5		6		Totals.		Ratio.
		Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	Pitot.	Meter.	
Verticals.	A	....	....	5.93	5.91	6.06	6.08	6.12	6.19	5.90	5.79	....	....	35.96	34.11	0.948
	B	5.11	5.07	5.45	5.79	6.19	6.33	6.81	6.96	5.68	5.60	....	....	35.24	36.95	0.955
	C	5.08	5.07	5.12	5.14	5.90	5.93	5.90	5.16	5.68	5.60	....	....	32.68	32.89	1.006
		....	....	5.04	5.05	5.96	5.98	5.94	5.19	5.90	5.60	5.76	5.68	33.34	33.79	0.986
		5.14	5.14	17.52	17.90	18.72	18.99	18.78	18.97	17.11	17.00	5.76	5.68	99.76	98.09	0.964
Totals.	A	....	....	94.98	95.36	94.07	95.06	93.72	93.44	93.06	90.05	....	....	95.96	95.45	0.995
	B	....	....	94.79	93.01	94.85	95.83	95.83	95.63	93.90	92.66	....	....	95.96	96.96	1.010
	C	....	....	12.07	11.57	12.86	11.97	13.52	13.06	12.85	13.17	....	....	50.11	49.07	1.021
		12.51	12.50	12.80	13.00	13.00	12.13	12.99	12.65	12.13	12.94	....	....	50.61	49.91	1.014
		16.66	16.36	16.77	17.04	16.71	16.97	16.10	16.90	15.47	15.00	11.00	10.77	98.66	98.51	0.991
		16.66	16.66	96.96	90.77	99.86	99.96	99.07	98.13	97.96	97.72	11.00	10.77	394.69	389.17	1.004
Ratio.	A	.....		0.995		1.010		1.010		1.010		.....		.....		
	B	.....		0.979		1.026		1.018		1.012		.....		.....		
	C	.....		1.046		1.080		1.066		0.981		.....		.....		
		.....		1.028		1.012		1.015		0.986		.....		.....		
		.....		0.995		0.988		0.988		0.968		.....		.....		
		0.999		0.969		1.007		1.011		1.009		1.021		1.004		

Remarks: *A*—tests in W. race at 0.7 gate; *B*—tests in E. race at 0.7 gate; *C*—tests in W. race at 0.87 gate.

It is not wholly clear to the writer, however, why the Pitot tube velocity should be in the neighborhood of 1½% less than the meter velocity at the greater depths. It is not improbable that this would have been partly compensated for, had the observations in the east race been continued to Depths 5 and 6, but probably not entirely. In fact, there seems to be a reciprocal relation, as noted above, between the readings in the two races. This would follow naturally, owing to the symmetry of the flow in the races as to the central dividing wall, and the fact that the meters always rotate in the same direction. Thus, if there is an eddy clockwise at a certain position in either race, there should be a symmetrically located eddy counter-clockwise in the other race, and these might have opposite effects on the meter, the Pitot tube not being affected in the same way.

It is not impossible that the Haskell meter was running a trifle faster near the bottom of the race than the actual still-water ratings would indicate that it should. This would result from the fact that the rating boat was not a rigid support, nor was the water absolutely still during the ratings. This would necessitate shifting the rate line of the Haskell meter toward its ideal position of a maximum number of revolutions. This, in turn, would diminish all discharge records based on still-water ratings. On the other hand, to be consistent, it would follow that the rate line of the Gurley-Price meter would have to be shifted toward the maker's rate line, which would make for a larger correction to be added to velocities by the Haskell meter when based on still-water ratings, thus leaving true velocities in Table 5 practically unchanged. In corresponding manner, all the ratios of Tables 6 and 7 would be increased, while the meter velocities would be less in the same proportion, the effect of which would be to leave the corrected true velocities corresponding to the tables unaltered, they being in fact those of the Pitot tube. Thus, discharge estimates would not be affected materially in either case. The most reasonable explanation, however, is that the Pitot tube itself is variously affected by small amounts in different parts of the raceways.

The object, however, is not to speculate on such matters, but simply to check the computation of a small correction to the velocity, which correction may be in error by 50% and yet not affect the discharge measurements by the meter by more than three or four tenths of 1 per cent.

Interpolating a percentage for Depth 1, which was not ob-

served in the tests, equal to the mean given for Depth 2, 1.055, and another in Depth 4, taking an average between the means for Depths 3 and 5, practically 1.000, there may be arranged the figures in Table 7.

TABLE 7.—AVERAGE CORRECTION FOR HASKELL METER, BASED ON COMPARISON OF CURRENT METER AND PITOT TUBE RECORDS.

Depths.	Ratio of velocity by Pitot tube to that by current meter, from Table 6.	Relative velocity in each horizontal, being a mean for Haskell meter.	Corrected relative meter velocity.
1.....	*1.055	10.30	10.76
2.....	1.055	11.98	12.51
3.....	1.001	13.50	13.51
4.....	*1.000	14.04	14.04
5.....	0.998	14.06	14.04
6.....	0.955	15.86	15.86
7.....	0.904	19.96	18.39
		100.00	100.61

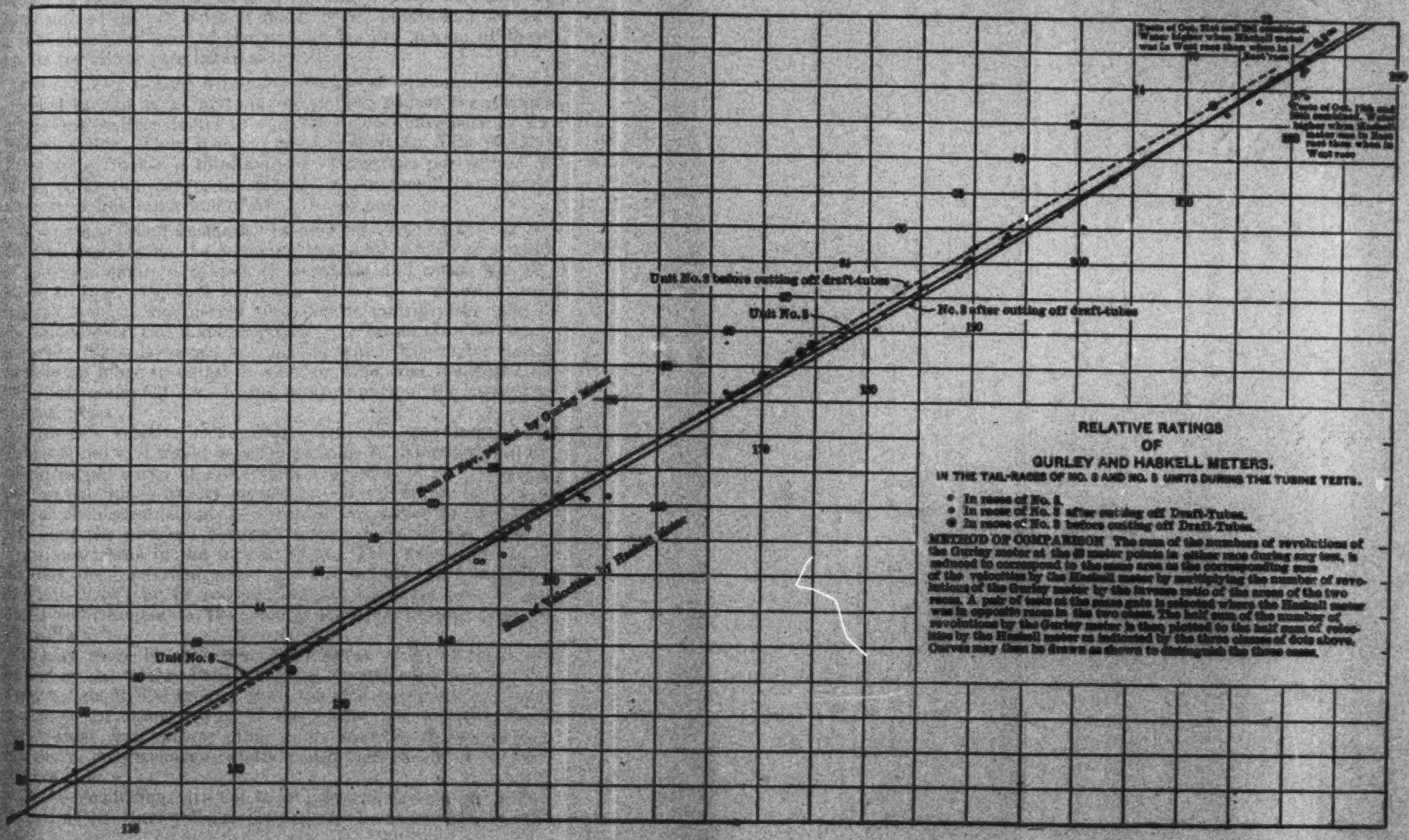
*Interpolated velocity ratio.

It follows from Table 7 that an approximate correction of 0.61% should be applied to discharges determined by the Haskell meter when used in these tail-races, and basing velocities on the still-water rating.

As a matter of fact, no direct use whatever was made of the still-water rating curves of the Gurley-Price meter, except to compute the corrections for the meters, which seem to be substantially verified by the Pitot tube tests. In reality, the Gurley-Price meter was rated relatively to the Haskell by comparisons of the simultaneous records taken by the meters in the two races during the numerous turbine tests.

While the Haskell meter runs in the west race, the Gurley-Price meter runs in the east race, and *vice versa*. If a pair of turbine tests be selected where the conditions are substantially the same, the Haskell meter being in the west race during one of the tests and in the east race during the other test, the total sum of the 84 velocities by the Haskell meter may be plotted to the total sum of the 84 numbers of revolutions per second by the Gurley-Price meter. If a number of such points be plotted, the curve drawn through them will represent the functional relation between the sum of the 84 velocities by the Haskell meter and the corresponding total sum of the numbers of revolutions per second by the Gurley-Price meter at the 84 meter points in the two races.

PLATE XXVI.
TRANS. AM. SOC. CIV. ENGRS.
VOL. LXXVI, No. 1268.
BROAT ON
CUP AND SCREW CURRENT METERS.



RELATIVE RATINGS
OF
GURLEY AND HASKELL METERS.
IN THE TAIL-RACES OF NO. 3 AND NO. 5 UNITS DURING THE TURBINE TESTS.

- In races of No. 5.
- In races of No. 3 after cutting off Draft-Tubes.
- In races of No. 3 before cutting off Draft-Tubes.

METHOD OF COMPARISON. The sum of the numbers of revolutions of the Gurley meter at the 48 meter points in either race during any test, is reduced to correspond to the same area as the corresponding sum of the velocities by the Haskell meter by multiplying the number of revolutions of the Gurley meter by the inverse ratio of the areas of the two races. A pair of tests at the same gate is selected where the Haskell meter was in opposite races in the two cases. The half sum of the number of revolutions by the Gurley meter is then plotted to the half sum of velocities by the Haskell meter as indicated by the three classes of dots above. Curves may then be drawn as shown to distinguish the three cases.

As the two races are so nearly alike, it may be accepted that, on the average, half the total sum of the 84 velocities will correspond to half the total number of revolutions per second at the 84 meter points, as a functional relation between the total sum of the velocities at the 42 meter points and the corresponding total sum of the revolutions per second at these points for either race taken separately.

Plate XXVI is such a relative rating curve, compiled from selected turbine tests, and may be used to reduce the records of the Gurley-Price meter to what they would have been by the Haskell meter. Thus, if in any tests on Unit No. 5 the Gurley-Price meter makes a total sum of revolutions per second of 50, then, by this curve, the Haskell meter would have made a record indicating a sum of 149.3 ft. per sec.

It was not found necessary to have any regard for the individual velocity by the meter at any point, except as a part of the total sum. A system of constants and ratios was devised, so that, to obtain the mean velocity in a raceway during any tests, it was merely necessary to multiply the sum of the velocities at the 42 meter points by a factor obtained from a curve. This, however, is a matter which the writer hopes to take up more in detail at another time, and therefore, he will confine himself here to the performance of the meters in the tail-races.

With this relative rating curve and the percentages of Tables 3 and 4, it would be quite possible to determine the absolute rating curve of either meter at each of the 84 meter points; but this is hardly necessary. It will suffice here, as a matter of interest, simply to conclude this paper by determining what the average absolute rating curve of the Gurley-Price meter was in the turbine tests. This may be done by dividing the numerical value of the abscissas and ordinates of Plate XXVI by 42 and plotting the resulting pairs of reduced co-ordinates to the corresponding reference lines in Plate XXV.

It may there be seen that the number of revolutions per second by the Gurley-Price meter in the tail-races was, on the average, about 6% greater than the still-water rating would indicate. In other words, if the writer had relied on this meter alone, without any other guide than the still-water rating curve, his discharge results would undoubtedly have been 6% too high.

These conclusions are not to be taken as casting any reflections on the Gurley-Price meter, which according to the

writer's experience, is an admirably constructed instrument. In fact, the results could not have been obtained without it. The rating of the meter was perfectly definite at each of the 84 meter points in the races, but could not be determined directly by the still-water rating, which, in reality, is the only thing at fault. The still-water rating should never be applied without regard to the probable deviations of the speed of revolution due to disturbances in the water. An excellent check on the meters is to rate them where operated with a Pitot tube.

ADDENDA.

Since the foregoing was written, the writer has had a very instructive experience with several types of meter used simultaneously on a complicated network of mountain streams. The results of oscillating the meters have confirmed the general conclusion that in all cases, relatively, cups are accelerated considerably, while screws are retarded slightly, in turbulent water. The errors of the cup meter, based on still-water ratings, were from 3 to 6 times greater than those of the screw, and in the contrary sense.

Design of Meters.—The principal desideratum of a current meter is that it should give the resolved component of velocity in a direction fixed relatively to the meter. The fact that a cup over-registers in turbulent water while a screw under-registers, gives a basis of design which may be used to produce a meter possessing this characteristic more or less rigidly. If the blades of a screw are "cupped" to the proper extent, and in the right sense, the effect may thus be toward neutralizing the retardation which the screw would otherwise suffer.

There are other ways of producing such a meter. Professors Greene and Moody, of Rensselaer Polytechnic Institute, have conducted a series of experiments there which resulted in the production of a meter practically giving only the resolved components of velocity.

A conclusion to be drawn from these experiences is that a tail, or rudder, is a useless appendage to a meter used in stream gauging. The meter should be held rigidly in the stream or conduit, giving only the component of velocity perpendicular to the cross-section. A cup meter would give better results in turbulent water if it had no tail, but was simply allowed to run at the end of a vertical rod like an inverted cup anemometer.

The recording device for a meter designed to be held rigidly n the current should register positively for down-stream cur- ent and negatively for up-stream current. There are cases here the current beneath the surface is up-stream; and the ld forms of meter make no distinction, as they should.

Accuracy of Velocity Determinations by Current Meters.— Under given conditions, the current meter is a very accurate nstrument. To prove this, it is only necessary to take a series f observations at a given meter point, or better, at a given et of meter points, when conditions at the gauging section are onstant. Repetitions of these observations will give results hecking within 1 per cent.

It is not even necessary to take observations under constant onditions, as is shown by the writer's plottings of the sums f the metered velocities at selected sets of meter points t various gauging stations. These curves are drawn through he plottings of points the co-ordinates of which are the ele- ation of the water surface at the given gauging station and he sum of the velocities at a selected number (25 to 100) of eter points in the cross-section. In shallow streams the eter points should be at mid-depth.

Even in the case of shallow, turbulent stony streams, such lotted points all lie within 1% of the finally determined curve, hus showing that the performance of the meter, be it of rew or cup type, is uniform and reliable.

The main sources of error are in the application of the still- ater rating, the determination of the section area, and the termination of the distribution of flow through the cross- ection. The errors due to an erroneous determination of the istribution of velocities are frequently styled the "errors due the method of calculation."

Distribution Factor.—If the discharge and section area are termined accurately for any one gauging, the mean velocity the section may be divided by the sum of the velocities at selected set of meter points. This ratio may be called the istribution factor for the corresponding stage of the water. this way, corresponding values of the distribution factor nd stage of the river may be determined and plotted, the co- rdinates being the elevation of the water surface and corre- ponding value of the distribution factor. If the work has en good, the points will plot as close to a smooth curve as e plotting of points representing the sums of velocities at e selected set of meter points.

Section Area.—The section area, next to the error in applying the still-water rating, is probably the most uncertain element of a discharge determination, where the stream is shallow and stony. Nevertheless, it has been ascertained that the surface profile of such streams at reasonably good stations is a function of the stage of the water, in many cases being simply a horizontal line. By taking a minutely accurate profile of the bottom of such a stream along the cross-section, and a number of surface profiles at various stages, the section area may be plotted to the corresponding elevation of water surface. This is another element for the accurate determination of a discharge curve.

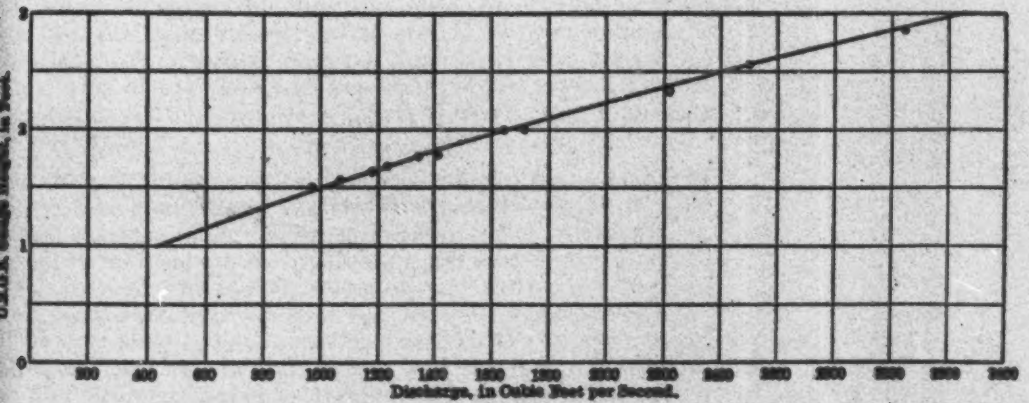
Statistical Synthesis of a Discharge Curve by Means of its Generating Elements.—According to the definitions given above, there are three principal generating elements of a discharge curve, all of which may be exhibited as curves plotted to the elevation of the water surface at the cross-section. These generating elements are, respectively, the sum of the velocities at a selected set of meter points, the distribution factor, and the area of cross-section.

If, for any given stage of water, the corresponding values taken from the curve of sums of velocities and the curve of distribution factors be multiplied together, the result is the mean velocity in the section for that stage. The product of this mean velocity and the section area taken from the area curve for the same stage is the discharge for that stage. In this way the discharges of the stream may be computed for all stages and plotted as a finally determined discharge curve.

The method is as strictly statistical as though the laws of probability had been applied formally, and the result is practically as satisfactory and infinitely easier to obtain. Moreover, errors are immediately detected and located.

Good work on the mountain streams of North Carolina and Tennessee has shown that individual discharge determinations based on the foregoing processes will plot within 1 or 2%, as extreme errors, of the final discharge curve.

PLATE XXVII.
TRANS. AM. SOC. CIV. ENGRS.
VOL. LXXVI, No. 1288.
SMOAT ON
CUP AND SCREW CURRENT METERS.

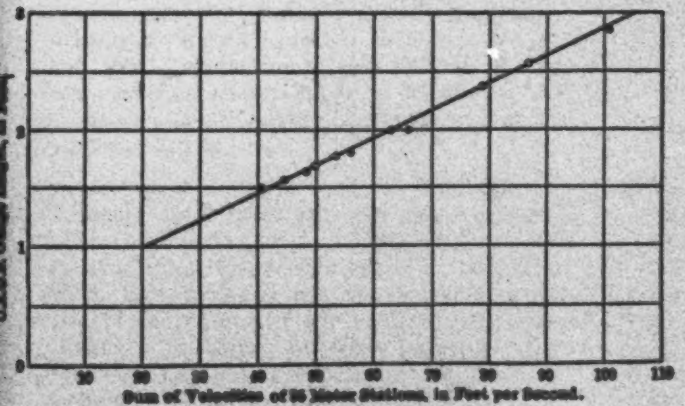


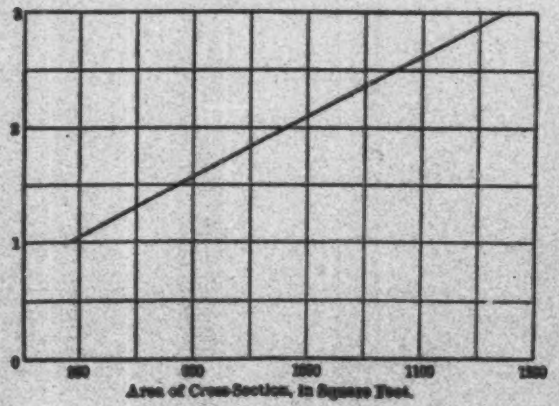
DISCHARGE CURVE FOR TUCKASEGEE RIVER AT BRYSON, N. C.

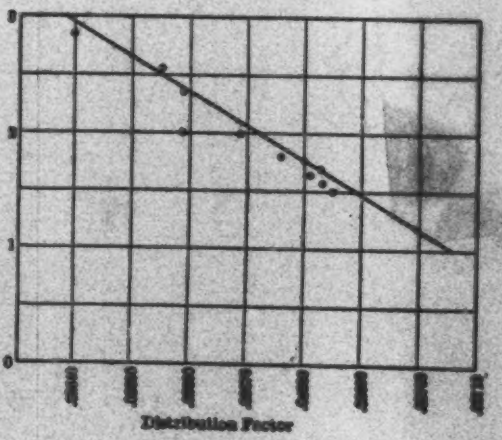
- Observations with Gurley Meter
- Observations with Haskell Meter

The discharge curve has been computed from the elementary curves obtained from observations with the Haskell Meter.

The points spotted on the discharge curve indicate the individual discharge obtained from each gauging.







Distribution of Flow.—The distribution of flow is determined in the ordinary manner by vertical velocity curves. It is best, however, to be systematic. A good system is to determine the ratio of the mid-depth velocity to the mean velocity in each vertical for the whole range of stages of the river. The writer has used an average value of these ratios for each stage of the river, by which the mean mid-depth velocity for the corresponding stage is to be divided, in order to obtain the mean velocity in the section before computing a discharge. In practice, a curve may be drawn giving the mean value of the ratio for each stage of the river. The determination of this ratio is a different thing from a gauging for discharge.

Discharge Gauging.—As described above, the writer prefers to take gaugings of shallow rivers at mid-depth at equidistant stations along the cross-sections. The individual discharge is then computed by dividing the sum of the products of the corrected mid-depth velocities and their corresponding areas by the average value of the before-mentioned ratio for the proper stage. The discharges at the ends of the section, below obstructions in the stream and around and through piers of bridges, should be treated separately under the title "end discharges" or "additional discharges." This additional discharge may be plotted as a function of the stage of the river. Such a plotting shows whether the calculation has been made on a consistent basis by forming a well-determined curve. Otherwise, the computer has varied his method of attack inconsistently.

Error in Using Average Ratios.—Undoubtedly, an error is made in using an average ratio of any sort, unless that average be determined properly. Thus a time average and a space average of a quantity are two entirely different things. It is important, therefore, to use the correct form of averages. However, if the values of the ratio of mid-depth velocity to mean velocity in thirty or forty verticals at a station of fairly uniform depth and velocity all lie between 1.10 and 1.18 as extremes, with an arithmetical average of about 1.14, no serious error can result in using such an average value. In fact, in this particular case, a detailed computation and one based on the average value of 1.14 differed by only one-seventh of 1 per cent.

Room for Research.—In the writer's opinion, it would pay scientific investigators to develop a meter which under all con-

ditions would give the resolved component of velocity in a given direction, rather than to attempt to determine any functional relation between the deviations of cup and screw meters from their still-water ratings. In the foregoing studies of the results at Massena it was thought sufficiently accurate to consider the error of the cup meter about six times the error, in the contrary sense, of the screw meter. This ratio is undoubtedly a variable, but no serious error can result by assuming it to be constant where the extremes observed would make less than 1% difference in the discharge, as was the case in the turbine tests at Massena.

Practical Application of the Methods.—Table 8 exhibits the results of a number of discharge determinations at a station where the turbulence of flow is at a minimum. In fact, the disparity between the records of the Haskell and Gurley meters is less in these observations than for those at any of the other stations operated in North Carolina and Tennessee. The average ratio of mid-depth velocity to mean velocity in the vertical, for 45 vertical velocity curves, is 1.055. The curve has not been drawn.

TABLE 8.—Results of a Number of Discharge Observations Taken at the Station at the Wagon Bridge, Bryson, N. C.

Meter.	Gauge height.	*Sum of velocities in 25 verticals.	Section area.	Distribution factor.	Discharge.	Mean velocity.
Gurley	1.80	40.38	686.0	0.03[illegible]	[illegible]	1.[illegible]
Gurley	1.67	44.81	690.8	0.03[illegible]	1[illegible]	1.[illegible]
Gurley	1.64	46.10	811.7	0.03[illegible]	1 170	1.[illegible]
Haskell	1.66	46.66	821.3	0.03[illegible]	1[illegible]	1.[illegible]
Haskell	1.77	48.25	906.4	0.03[illegible]	1[illegible]	1.[illegible]
Gurley	1.80	46.97	842.1	0.03[illegible]	1 [illegible]	1.[illegible]
Gurley	1.89	48.73	880.3	0.03[illegible]	1 [illegible]	1.[illegible]
Gurley	2.09	48.94	920.3	0.03[illegible]	1 [illegible]	1.[illegible]
Haskell	2.27	52.96	1 093.7	0.03[illegible]	2 [illegible]	2.[illegible]
Haskell	2.16	50 [illegible]	1 027.3	0.03[illegible]	2 [illegible]	2.[illegible]
Gurley	2.09	50[illegible]	1 144.3	0.03[illegible]	2 [illegible]	2.[illegible]

*The velocities are here based solely on the still-water ratings of the meters.

Plate XXVII shows the plottings of the main elements of the discharge observations of Table 8, according to the statistical methods described herein. The discharge curve is determined by the three elementary curves, as already explained. The elementary curves are plotted from the records of the Haskell meter.

DISCUSSION.

W. G. Price, M. Am. Soc. C. E. (by letter).—This paper gives the results obtained from a very large number of observations, and should be of much value. Before accepting these results as perfectly reliable, the writer would be pleased to know if the meters, in both the rating and stream tests, were suspended in precisely the same way and by supports of the same size?

Were weights used in both cases; and were they always the same distance from the wheel?

Was the skiff so far from the wheel that it did not push the water ahead of itself a trifle and thus reduce the rate of revolution of the wheel? In some cases, a steamer ascending the Upper Mississippi will check slightly the flow of the water some hundreds of feet ahead of itself.

The writer has had an extensive experience with current meters during a period of seventeen years, beginning with 1879, during which time he measured the flow in the Mississippi, Missouri, and Ohio Rivers, and their large and small tributaries, many times, and in many places. The following propositions are the result of his experience:

The thread of a perturbed current, of course, is longer than that of a steady current. A meter of the cup type, without a vane, measures the thread of the horizontal current perturbations, but when provided with a vane, it measures a trifle more than the thread of the horizontal perturbed current. This is due to the effect on the vane of the perturbed current which swings the wheel transversely to the current. If a cup meter with no vane is fixed on a vertical rod, the current perturbations moving up and down in the vertical plane will decrease the revolutions of the wheel and thus offset the increase due to the horizontal perturbations. This action is due to the fact that the top and bottom faces of the meter wheel present a propeller-shaped surface to the water, and when vertical currents strike the wheel they tend to turn it in the opposite direction from that produced by the water flowing against the cups. For this reason the vane should not be used in streams shallow enough to permit of it being omitted, if there are perturbed currents. Larger streams, when the gauging station is carefully selected, are not perturbed to such an extent as to cause a serious error in meter measurements.

A meter of the propeller type will measure less than the thread of the perturbed current, because of the inability of the

vane to keep the face of the wheel at all times precisely normal to the current. A current striking a propeller wheel sidewise does not increase its revolutions, as is the case with the cup meter. Each type of meter, in clear, straight, running water, will give the same accurate results, provided it has been accurately rated and is supported in the stream in precisely the same way as when rated, or by a method which does not produce an increase or decrease of current at the meter wheel.

When a weight is attached to the supporting rod under the meter, it reduces the discharge area and increases the velocity of the water in its vicinity, and thus increases the rate of revolution of the meter wheel. If the weight is placed 6 in. below the meter, the wheel, in each type, will run much faster than when the weight is 12 in. below the meter. A difference in the location of the weight, or the use of the weight in one case and not in the other, will produce all the difference, noted by the author for the Price meter, between ratings and stream measurements.

The propeller type of meter is often made to run more slowly between ratings and stream measurements by a slight quantity of grit blowing into the bearings, or being carried in by the water. This type of meter is often made to run slow by a particle of dead grass or leaf (found moving in most streams) catching on the propeller. The propeller type of meter does not free itself from such debris, as does the cup meter.

When meters are rated in still water, it is necessary to wait 10 min. or more after each passage of the meter for the water to become still again. If the wind is blowing against the surface of the water, variable and sometimes rotary currents will be produced, which will make the rating inaccurate. The surface currents will run in one direction and the under current in the opposite direction. For this reason, the meter should be rated at a depth of more than 2½ ft., and in water more than 5 ft. deep.

A rating taken in running water is likely to be the most accurate, because the running water carries away the disturbing currents produced by the movement of the meter.

When a cup meter is accurately rated in still water and in ordinarily steady running water, the two ratings will be the same within a small faction of 1%, and the rating curve can be drawn through all the plotted points obtained by the rating, so that no point will vary in revolutions as much as 1% from the curve.

The writer has used a Morse paper tape register and electric device to start and stop the register, or mark the paper tape, at the instant of passing the cross-wires suspended over the 200-ft. base, so that the fractions of revolutions of the cup meter wheel were determined at the beginning and end of the run; and such a rating in still water, with almost no wind, located all the plotted points within a very small fraction of 1% of the number of revolutions from the rating curve as drawn.

The ratings of both the Haskell and Price meters given on Plates XXIII and XXV are inaccurate, as the plotted points indicating the number of revolutions vary entirely too much. The errors in the Price ratings are apparently much greater than in the Haskell ratings.

Mr. Groat has conducted a series of observations in one tail-race where the currents were quite divergent, and the writer submits that the result of his experiment, treating as it does of one special condition, cannot be taken, either directly or by inference, to apply to general conditions of measurements of the flow of streams.

Under such peculiar conditions, where there are cross-currents, as in the Massena experiment, it is possible that the propeller type, owing to its peculiar construction, is less affected by such currents than the cup type; but if the propeller type were better for the measurement of streams where accurate measurements are impossible, owing to cross-currents, this fact would not indicate that such meters are better for general use.

A perfect still-water rating, of course, is what is required when the instrument is to be used in the measurement of straight, flowing streams. The usual rating in running water is made only to secure the same result as would be obtained by a perfect still-water rating. The small variations of the current from a straight line, as seen at the gauging section in most streams, makes only a negligible error in meter measurements.

A meter measures approximately the length of the curved thread of the current; therefore, if the thread is very divergent, inaccurate results will be obtained with any meter.

A gauging section having a perturbed current which would cause an error of 6% would give evidence to the eye by the boiling of the water, and would make the experienced observer hunt for a better section. However, better sections cannot possibly always be found.

A gauging section which has an up-stream current should never be used, and one which has very divergent currents can not give accurate results with any method of measurement.

The first meter used by the writer had a cup wheel which revolved in a horizontal plane. It was designed by Gen. Ellis, and had been used by him in the Connecticut River. This meter did good work in water which was absolutely free from grit. Floating organic matter, such as leaves and grass, did not often affect it, as the turning of the wheel caused such debris to free itself. When the attempt was made to use it in the muddy water of the rising Ohio in 1882, it gave very inaccurate results, owing to grit getting into the bearings, which made its rate variable. The writer was then furnished with two very finely constructed meters, designed by Clemens Herschel, M. Am. Soc. C. E., and made by Buff and Berger especially for this work. Each was of the propeller type, with horizontal shaft, having agate bearings, and each was provided with a vane to hold the meter in line with the current in both the vertical and horizontal planes. They were as perfect instruments of the propeller type as the writer has seen.

These meters were tested by rating them in clear water, and gave good results. They were then rated in a bayou of roily water, an overflow from the Ohio, and the results were very inaccurate, owing to grit getting into the bearings, and leaves and other debris catching on the wheel and continuing to revolve with it. They were tested in the turbid Ohio River with no better results.

It was absolutely necessary to have a meter which would do accurate work, if the great Ohio flood of 1882, which was then on its way, was to be accurately measured. In designing and constructing what is called the Price meter, on this occasion, the cup type of wheel was adopted, for three reasons: The friction of the bearings is so small that this wheel can measure sufficiently low velocities, which is not the case with the propeller type; the revolving wheel will clear itself of debris; and, by using a vertical shaft, with inverted cup bearings filled with air and oil which will stay in by capillary attraction, no water with its load of grit can enter. The friction of the bearings thus becomes a constant quantity. The well-known and successful operation of these meters is due to these three features, which the writer believes cannot be secured by any other design.

The propeller type of meter, designed by Mr. Herschel, was in service before the Price meter, but has had quite a limited use, while several thousand Price meters have gone into service. This test of time, under all kinds of conditions, indicates that the cup meter is the most efficient for general purposes.

The writer believes that with an accurately rated cup meter of the type having no vane—which is much the better design for shallow, perturbed streams—more accurate results could have been secured at Massena.

E. E. HASKELL, M. Am. Soc. C. E. (by letter).—The writer has been greatly interested in the results set forth in Mr. Groat's paper, for he has never had occasion to use current meters under just such conditions.

The current meter was designed originally to measure velocities in open channels. It has developed into two distinct types: those having screw wheels and those having cup wheels. The first current meter, "Woltman's Mill," more than 100 years old, was of the screw wheel type. This meter has undergone various changes in form and in the mounting of its wheel, and, on the whole, has proved to be very accurate and reliable. The origin of the cup wheel meter is not as definite. It has undergone various changes, and the cups have been of various forms, namely, cones, hemispheres, and combinations of cones and hemispheres. Although a great deal of good work has been done with meters of this type, they have not shown themselves to be anywhere near as reliable as those of the screw wheel type. In the writer's judgment, this is due to the fact that they do not always present the same area and form of wheel to the current pressure. The tilting of the meter, even through small angles, changes these, and consequently changes the rating curve or equation. In current meters of the screw wheel type, such tilting through small angles makes but a slight change in the area and form of wheel presented to the current pressure, and, accordingly, they follow much more closely their rating curve or equation.

In the last paragraph on page 836, the author states, as follows:

> "A conclusion to be drawn from these experiences is that a tail, or rudder, is a useless appendage to a meter used in stream gauging."

The writer's experience will not allow him to accept this conclusion. In a large river, the difficulty of holding the axis

of the meter perpendicular to the cross-section becomes so great that it is out of the question. In large streams it is necessary to measure both factors, velocity and direction, and reduce to obtain the velocity normal to the cross-section. In small streams or tail-races it is possible to hold the meter rigidly in place; but, when thus held, if the direction of the current makes an angle with the horizontal, that is, strikes the wheel of the cup meter either on the top or bottom of the cups, it will over-register as readily as if running in "eddies" or "boils." The amount of this over-registration depends on the angle which the direction of the current makes with the horizontal, and can only be determined by some check method.

It is not at all clear to the writer why a still-water rating of a current meter should not give an entirely satisfactory result. In all cases where the elements of the current in the open channel are reasonably parallel, the meter is working under almost the same conditions as when drawn through still water. In one case the meter is free and the water moving, and in the other the meter is free and moving, and the water still.

The following test of a direction current meter was made after it had been rated in still water. It was made in a large tidal channel, free from "eddies" or "boils," where the elements of the current were parallel. Each comparison was made by running the meter for 10 min., and in this time running ten large cylindrical can-floats, alternating on each side of the meter. The determined velocities are in feet per second, as follows:

Float	1.04	1.29	1.55	1.94	2.56	2.65	2.76	2.80	3.08
Meter	1.05	1.28	1.55	1.96	2.59	2.64	2.74	2.82	3.11

The greatest uncertainty in the results obtained with cup wheel meters is caused by using such meters from an unstable support, like a boat, particularly if the weather conditions are such as to give the boat any rocking or pitching motion.

The author is deserving of much credit for his work and his paper. Well planned and well executed work cannot help but make for engineering progress.

CHARLES H. MILLER, M. Am. Soc. C. E. (by letter).—Although the writer has made scarcely any current meter observations during the past twelve years, and hence has not kept up fully with the progress in such work, he is much pleased at the opportunity to read such a clear presentation

of a series of observations, evidently made with much painstaking care; and is gratified to note such a complete verification, stated, however, in a much clearer manner, of a positive difference between a cup meter and a screw meter when running in perturbed water; which difference the writer noted just a short time before leaving the Government service, and has never had opportunity to investigate further.

Although the difference was then cited as being due to instability of support, in other words, the rocking of the skiff, this rocking was done for the purpose, not only of causing conditions actually to be found in the river on account of "boils" and "eddies," but to show the effects that might be expected should the skiff or support be moved otherwise than in a straight and even course, while taking a rating in still water. That the writer was familiar with this source of error a number of years ago may be noted by referring to a letter* written by him, in which, in speaking about the rating of meters in skiffs, it is stated that "a rating should never be taken in a skiff which is being pulled with the oars," and that "the observers should be cautioned about keeping the same positions and not swinging their bodies from one side to the other while the observation is being made." This same passage was noted by the late William Starling, M. Am. Soc. C. E., and referred to in his paper entitled "The Discharge of the Mississippi River."†

Mr. Starling's paper treats in general of the many difficulties attending the taking of discharge observations on the Lower Mississippi River, and explains the reasons for some of the apparently discrepant results published in those days, he having had access, at the time, to the large mass of data gathered by the writer and others then engaged in wrestling with the problem of determining the extent of, or in eliminating, errors. It must be remembered that the possibility of error is very great when measuring the discharge of a river in which a favorable cross-section has a width of approximately ½ mile, with a maximum depth of 105 ft. at times, where velocities of 9 ft. per sec. or greater are found, and a total discharge of 1 750 000 cu. ft. per sec. may be obtained. Under such conditions, it is impossible to anchor the boat or equipment, and it must be held on one spot, as nearly as possible, by means of the rudder and the propelling power, counter-

Engineering News, January 24th, 1895, p. 58.

†*Transactions*, Am. Soc. C. E., Vol. XXXIV, p. 347.

balancing the current and wind forces. Careful observations were made to determine how much movement actually took place. In fact, a large portion of the time in the field was devoted to checking the accuracy of the observations. It may be noted that the meters then used were of the cup variety. Some checks, however, were made by a system of double floats.

As noting some of the improvements that were being made from time to time, attention is called to the fact that, at a time as recent as 1891, the meter rating was considered as following a straight line, and the proper straight-line equation was calculated by the method of least squares, often, however, not until some time after the field observations had been made. About the date just mentioned it became customary to plot the rating observations and draw the curve conforming as nearly as possible thereto, from which a rating table was taken directly. Other tables were made to cover all necessary computations in the discharge work, and each station observation was calculated while the boat or steamer was moving to the next station, so that the total discharge was known a few minutes after the last velocity observation had been made. For instance, during the morning of May 4th, 1892, at Arkansas City, Ark., the discharge was computed at 1 733 676 sec-ft. as compared with 1 532 875 sec-ft. for the day before. Another observation, made during the afternoon, gave 1 741 526 sec-ft., showing that some marked change had taken place during that time. On the following day it had dropped back to 1 589 172 sec-ft., or to about the general average at that time. Under the old methods, the observations were not computed until some time, often weeks, after the field observations had been made.

As illustrating the fact that every method that could be thought of at the time was used to eliminate errors, it will suffice to say that, in the case of a large and persistent difference in the discharge, as found at two stations 90 miles apart, new meters were purchased, later they were interchanged, frequent ratings were made, and finally the observers exchanged places with each other; all this was done without finding a satisfactory reason for the difference. This was in 1892. During the high water of 1893 these same stations were again occupied, and further efforts were put forth to get accurate results. Mr. Starling, in the paper previously cited, has this to say regarding this work:

"In 1893, the discharges at Arkansas City and Wilson's Point agree fairly well; and when checked by the results of the flanking observations, they present a very coherent mass of data, affording the most trustworthy measurement of the extreme high-water discharge ever obtained on the Mississippi."

Too much stress cannot be placed on the fact that it is just as important to avoid errors in rating meters as in taking the actual discharge observations; and the writer is strongly of the opinion, based on long experience in the field, that by far the larger part of the error is due to the fact that ratings are usually made under physical conditions which are widely variant from those under which the discharge observations are made. For instance, if the observations are to be made from a steamer, then the ratings should be made from the same or a similar steamer, and in dead water, if possible, although they can be made accurately in moving water, provided the movement is smooth, generally uniform, and slow enough to permit the taking of slow velocities in the downstream direction. Care must be exercised in keeping the meter below the influence of the "drag" occasioned by the steamer hull moving through the water.

Necessarily, the official reports, on account of limited space, as a rule, can contain but a brief explanation of methods and results; and, naturally, these reports incline toward the better showings, failing in general to recognize the fact that the publication of actual failures will often hasten the time of the final solution of the problem.

It may be of interest to know that the first forms of meters were of the wind-mill, screw, or propeller type; that is, the vanes turned, in a plane which was perpendicular to the direction of the current. These were used on South American rivers in 1871.

To eliminate the tail or rudder appears to be a move in the right direction, but a vertical rod could hardly be used with success in gauging a stream as large as the Mississippi, and it would no doubt be possible to work out a design which could be mounted concentrically on the cable which is now used to lower the meter, with its attendant lead weight, to depths of 60 ft. or more, affixing the tail or rudder to the lead weight, and placing the latter so far below the meter that it would not influence its running.

JOHN C. HOYT, M. Am. Soc. C. E.—Although more than fifty devices for measuring the velocity of water have been patented, the only meters which have had general use are the Price, Haskell, Fteley, and Ellis, or modifications of these.

Each of the various meters has first been devised to meet the requirement of some special condition, and may or may not be applicable to other conditions. Therefore, a current meter should never be used for other conditions than those for which it is designed or has been found to be applicable.

In 1888 the United States Geological Survey began gauging streams of all sizes and in all sections of the country. These streams presented an infinite variety of combinations of range in depth, width, and velocity, were often remote from railroad or other regular transportation facilities, and were consequently difficult and expensive to gauge. No adequate instruments or methods had been developed for work of this varied nature. Furthermore, elaborate equipment and methods were out of the question on account of the limited funds. It was necessary to devise or adapt a current meter which could be readily carried in the field and operated by one man, either from a bridge, boat, cable and car, or by wading.

To fulfill these requirements it was essential: (*a*) that the meter should be simple and light in construction, with no delicate parts which easily get out of order; (*b*) that it should be simple in operation, including its preparation for use under any conditions, and its dismantling, cleaning, and boxing after use; (*c*) that it should offer a small area of resistance to the action of the water; (*d*) that it should have a simple and effective device for indicating the number of revolutions of the wheel; and (*e*) that it should be adaptable for use under all conditions.

After experimenting with various types, the engineers of the Survey developed a meter combining certain essential features of the Price acoustic and the large Price electric meter. This is known as the small Price electric meter, and is now in general use in the Survey work. Modifications in its construction have been made from time to time, until now it represents the ideas of many engineers based on results of more than twenty years of experience in stream gauging.

The limitation of the Price meter pointed out in this paper, namely, that it may be effected by cross-currents, has always been recognized by its designers and users. Therefore, special care has been taken to restrict its use to work where the conditions are such that errors from this cause will not affect

the final estimates of discharge. These requisite conditions are: (*a*) a fairly smooth bed; (*b*) a measurable and steady velocity of current; and (*c*) a stationary stage during the measurement. The velocity of the current should vary gradually throughout the section, which should show no marked eddies, cross-currents, or boils, and its mean should not be less than 0.5 ft. per sec. at low stages. After visiting hundreds of gauging stations, on streams of varied character, in all sections of the United States, the speaker is convinced that only the exceptional station is not or cannot be located in accordance with these requirements. This statement is made in order to correct any impression which may be drawn from Mr. Groat's paper, that the Geological Survey records, based on measurements with the small Price meter, generally involve large errors. More than two hundred engineers have been engaged in the stream gauging work of the Survey for various periods during the last twenty years, and, as far as known, no valid criticism of the methods used has ever been made which was not fully appreciated by the Survey engineers; and they have made combined effort to correct, as far as possible, each defect in the work as soon as it is discovered. The instruments and methods have been subject to continual change, and old have been supplanted by new whenever the new have been proved the better. Constructive criticism of the work is, and has always been, welcomely received and acted upon, and this opportunity is taken to appeal to engineers who are interested in the use of stream flow records for more constructive criticism and for co-operation in raising this branch of hydraulics to the high plane for which all who are engaged in it are striving.

A few points in Mr. Groat's paper may be referred to briefly:

1.—The paper calls attention to the recognized fact that the differential meter is affected by cross-currents.

2.—It is believed by the speaker that the methods used in carrying on the work from which the conclusions in the paper were drawn, and the magnitude of the results obtained, are both open to question.

3.—Unfortunately, the methods are described only in a general way, and various factors which might affect the results materially are not adequately presented. Furthermore, sufficient data for making any exhaustive study of the results are not given. Therefore, any detailed discussion of the work is impossible.

4.—The large Price meter used in the work is of a type which has not been used for several years by engineers who are most familiar with stream gauging. In the work of the Geological Survey, it was abandoned several years ago, when fifty meters of this style, all practically new, were condemned and replaced by the small Price meter, which was found to give more satisfactory results.

5.—The reader is left in great doubt and uncertainty in regard to the standards used in the comparisons. Though the Haskell meter used may not be seriously affected by cross-currents, there are no experimental data, as far as known to the speaker, which show that this meter gives results any more accurate under the adverse conditions stated than does the Price meter.

6.—The results obtained with an unrated Pitot tube do not appear to be sufficiently conclusive for any final deductions. The Pitot tube itself has had no extended use in open channels, its behavior has not been fully investigated, and, in the limited experiments which have been made with it, many questions have come up which leave an uncertainty as to its action. It has been demonstrated that its rating does not hold near the sides of a canal, and it has also been shown that it will not measure the true velocity when the opening is not in line with the current.

7.—The paper points out a well-known defect in the Price meter, but gives no remedy, and offers no substitute which can be used under a wide variety of conditions.

8.—The assumption that the differences shown by the so-called still-water ratings of the meters apply when the meters were used in the canal is questionable. The amount of difference between the Price and Haskell meters, when rated under the conditions mentioned, will depend on the amount of disturbance introduced into the rating; as the Price meter will record, not only the horizontal motion, but also the vertical motion and the cross-currents.

9.—The experience of the Geological Survey shows that accurate ratings of the current meter cannot be made from boats, owing to the errors introduced in connection with obtaining the various factors entering into the rating. Changes in the methods of rating by the United States Geological Survey, the Bureau of Standards, and the Rensselaer Polytechnic Institute have changed the results of ratings about 3 per cent.

10.—The speaker is unable to see why one familiar with current-meter work would have attempted to use the Price

current-meter under the conditions found at Massena. Engineers of the Geological Survey have frequently refused to co-operate in work where similar conditions existed.

11.—The statistical synthesis method, as understood by the speaker, does not take into account the relative distribution of velocities and areas in various parts of the cross-section. The mean velocity in a cross-section, as defined by the Geological Survey, is obtained by dividing the discharge by the area, which will not give the same results as taking the mean of the velocities at various points in the cross-section. For example, a certain stream may have 50% of its flow in 10% of its cross-section. Furthermore, this method of computation has no apparent advantage over that ordinarily used, and has the disadvantage of being much more complicated, even if the results are of equal value.

12.—The question of the distribution of velocity in the vertical has been investigated most thoroughly by the engineers of the Geological Survey, who have found the mid-depth method to be the least desirable. The mean of the velocities at two-tenths and eight-tenths of the depth gives (without a coefficient) the velocity in the vertical, under all conditions of natural flow; and, next in value, the six-tenths depth method has been found to be the most satisfactory.

The only method yet devised for rating a current meter is by drawing it through still water. A close study indicates that no material error is introduced in the results obtained with this instrument on account of the method of rating. Large numbers of comparative measurements have been made with the Price current meter, calibrated weirs, and measuring tanks, all of which show that the meter, when properly used, will give results accurate within 1 or 2 per cent.

It has also been found that measurements at different points on a stream, where the conditions of measurement are entirely different, give results which agree closely. Many measurements have been made on two tributary streams and then on the main stream below, and the results check within the limits of accuracy necessary in work of this type.

C. W. Stanford, M. Am. Soc. C. E.—The speaker would like to ask Mr. Groat or Mr. Hoyt whether any of the current meters mentioned—the Haskell, the Price, the Ellis, or perhaps the admirable German instruments—after being rated in fresh water (still water, of course), have been used in salt water; and what percentage of accuracy can be obtained with such meters in salt water?

If such instruments have been rectified against corrosion, and against short-circuiting, can they be relied on when used in salt water?

B. F. Groat, Assoc. M. Am. Soc. C. E. (by letter).—If one will examine the papers and discussions concerning current meters published since the original study was made by Frederic P. Stearns, Past-President, Am. Soc. C. E., in 1879,* it will be found that there is much uncertainty among engineers concerning the reliability of these instruments, with which, up to the present time, there does not seem to have been any generally satisfactory and generally adopted practice. These facts are in sharp contrast to those connected with the use of other engineering instruments, such as the transit and level. No method can be deemed generally satisfactory until it meets the general approval of practitioners. So long as there is lack of agreement between various classes of current-meter observers, not only as to the general method of procedure, but also as to the reliability of various types of instruments, there can be no such thing as a satisfactory current-meter practice.

When it becomes generally realized that current meters obey their still-water ratings only when the conditions of flow are ideal, and that cup meters are affected in one sense and screw meters in the contrary sense, it will be apparent that there is a real reason for the diversity of opinion concerning the reliability of current-meter work.

The writer, therefore, was inspired by the hope that this paper might reopen the discussion and possibly put in motion an effort to improve the current meter.

Appended to the paper there is a brief description of a new system of taking discharge observations and a new method of constructing the discharge curve. This system and method have been applied most successfully in a number of cases, and are worthy of the attention of those contemplating a series of gaugings at one or more stations.

The method of synthesizing a discharge curve is not an invention of the writer which he is trying to introduce, but is a well-stablished method used by physicists and practicing engineers in determining various kinds of relations between observed magnitudes. It consists simply in separating a given investigation into its elementary parts and drawing a curve for each, the final relations being derived from the elementary curves or relations. The fact that the sum of the

*Transactions, Am. Soc. C. E., Vol. XII, 1883, p. 301.

velocities at a given set of meter points at a gauging station forms such an elementary relation, when plotted as a function of the gauge height, leads to the term "statistical."

The main advantage of the statistical method is that the entire series of gaugings, extending over a long series of years, may be connected into a consistent whole. The peculiar characteristics of a station may be studied from the elementary curves. If any change or break occurs in one or more of the elementary curves, a corresponding change or break has taken place in one or more of the physical characteristics or hidden conditions of the station. This is especially true of the sum of the velocities at a given set of meter points, because the sum forms a fixed relation between velocity and stage. The sum is chosen because, in taking a number of velocities, the accidental variations and errors in the velocities eliminate themselves. That is why, even at turbulent stations, a smooth curve can be drawn through the plotted values of the sum, with errors well within 1 or 2%, as extremes. It is not likely that changes in the hidden conditions at a station would be detected by any other method. They would be set down simply as unaccountable variations.

Another very important advantage of the statistical method is that it affords at once the most independent and most easily secured check on the velocity readings. Indeed, the sum of the velocities must plot on a definite curve, and this enables one to check the meter work at any newly observed stage with that at any other stage within 10 min. after all the velocities for the former have been recorded.

The writer is glad to know that his Conclusion 1, concerning cup meters, is generally recognized. Under certain nearly ideal conditions, such meters will give good results, but, the moment the conditions are changed in the slightest degree, the still-water rating becomes more or less inapplicable, with a resulting constant or systematic error.

Nevertheless, it would be perfectly safe to use a cup meter in turbulent water if, where used, it were rated with a Pitot tube. The fact that the meter runs with fidelity under such circumstances is another of the conclusions drawn in the paper, and one should not lose sight of this good quality. It may also be remarked that this is a fact which does not seem to have been generally recognized. Cup meters will undoubtedly have their uses, but improvements in the means for obtaining their ratings—not still-water ratings, but actual ratings at the time and place of use—are imperative. It will

do to talk about refined ratings when probable errors are reduced to values of less than from 3 to 5 per cent.

After reading the discussions one can scarcely shake off the idea that the niceties demanded for the conditions under which cup meters must be rated are altogether out of proportion to the degree of accuracy attainable with these meters in stream gauging. If a cup meter cannot be rated accurately from a boat when operated carefully, owing to changes in rating due to the slight irregularities of motion, what must be the effect on such a meter when subjected to the far greater irregularity of the motion of the water at a fairly good gauging station, to say nothing of the errors to be expected at a really turbulent station.

The writer believes that Mr. Miller made an important discovery in current-meter engineering when he noticed that cups over-register considerably and screws under-register slightly in agitated water. In due time this fact will impress itself on engineers generally, and lead to a meter which obeys its still-water rating more closely than any hitherto made.

The Haskell meter is so nearly correct under a wide range of conditions that it would seem to require only slight modification, as suggested in the paper, to render it almost independent of conditions. It would be a delightful task, for some one who has the time and means, to develop such a meter. Meantime, it cannot be too strongly urged on hydraulic engineers that a screw current meter is the most reliable kind for measuring the velocities of flowing water when using the still-water rating.

It may be well to define the terms "cup" and "screw," as the writer does not wish to apply the general propositions stated to every kind of instrument which may chance to be called a cup meter or a screw meter: A cup meter is one in which the rotating element operates on the principle of the Robinson cup anemometer, though the shape of the cups need not be limited to that of the hemisphere. A screw is a rotating element the surface of which would be generated by a straight line perpendicular to, rotating uniformly about, and moving uniformly along, the axis of rotation.

One would also hesitate to apply the propositions to meters having large or badly designed frames which would be likely to interfere with the action of the water on the runner. Although the frame of the cup meter is at the rear of the runner, it has decided and different effects on the rating of the

instrument when turned somewhat to the right and then an equal angle to the left of the line of motion.

The writer is more than pleased to have Mr. Price's open-minded discussion. The cup meter is very ingenious, and the means which Mr. Price has adopted to protect the bearings and secure uniformity of friction have probably been the cause of the continuance of this meter in the Government service.

Mr. Price may be assured that the meter was suspended in precisely the same manner during the turbine tests as in the ratings. This applies also to the stream tests. No weights were used in any case, and the meter wheel was about 7 ft. in advance of the stem of the rating boat. The reaction of the boat on the screw must have been slight indeed, as the ratings from a car at the Rensselaer Polytechnic Institute do not differ materially from those by the boat.

Fig. 1 shows the rating boat, and below it the rod used to support the meter. The hooks on this rod may be adjusted so that any desired series of depths may be secured. From the staging on which the observer stood a ⅝-in. rod extended across the tail-race at a fixed elevation. The meter was attached to one end of a ¾-in. rod, about 2 ft. long, the other end of which was screwed into the supporting rod. There were seven hooks on the supporting rod during the turbine tests, any one of which could be hooked over the ⅝-in. rod on the staging, thus immersing the meter to the corresponding depth. Six rope clips were attached to the ¾-in. rod at the verticals in which the meters were to be operated. The rope clips served as stops at which to hold the meter rod, when taking observations in the verticals.

Fig. 2 is a rough sketch of the Pitot tube and supporting rod. The Pitot tube (to the right) is a copy of "Tube *N*," as described in Mr. White's monograph, referred to in the paper. The supporting rod (to the left) was designed to be operated from the staging in the tail-race, in the same manner as the supporting rod for the meters. On Fig. 2 is shown one of the hoops to engage the ⅝-in. rod on the staging, and also the eyes on both the Pitot tube and meter supporting rods to which a guy wire was attached near their lower ends, thus holding the rods and preventing bending.

Mr. Price states that the meter of the propeller type does not free itself from such debris as dead grass and leaves. This is too broad a statement, for there is at least one meter of that type which does free itself, and that is the Haskell. This meter has been used by the writer many times in streams

carrying much dead grass, leaves, twigs, sand, and mud. On no occasion did it catch the slightest particle or give any evidence of being affected thereby.

This is due to the effective shape of the runner, which Dean Haskell has undoubtedly designed expressly for the purpose. The up-stream end of the wheel is brought down to moderately pointed or conical nose which sheds all debris carried by the water.

The question of friction in a current meter is very interesting. Throwing out the case of low velocities, the necessity seems to be, not so much for a small amount of friction as for constancy of amount. If the resisting torque is large but constant, a rating should be fixed just as exactly as in the case where the friction is small and constant. Notice, too, that there is a resisting torque caused by the hydraulic skin friction on a screw, which can be made as large as desired by lengthening the vanes along the axis. In this respect, the screw is just as much a differential meter as the cup meter.

The retarding skin friction has a much longer lever arm than the bearing friction, and has a much larger resisting torque, so that the bearing friction of a screw meter offers a resistance of secondary importance. Further, the resisting skin friction is a fixed function of the velocity, varying approximately as the square thereof. Hence it is clear that the principal portion of the resisting torque is fixed for each velocity and cannot be changed. It follows that, if the meter is kept in only fair condition, the rating is not affected seriously by moderate changes in bearing friction. The truth of this was tested in the experiments at Massena by taking part of a rating while the bearing was dirty and stiff, then completing the rating after the meter had been cleaned and oiled. Let the reader select from ratings *E* and *F* of the Haskell meter, Plate XXIII, the points taken before cleaning and oiling the meter. The Haskell meter is not sensitive to moderate changes of bearing friction.

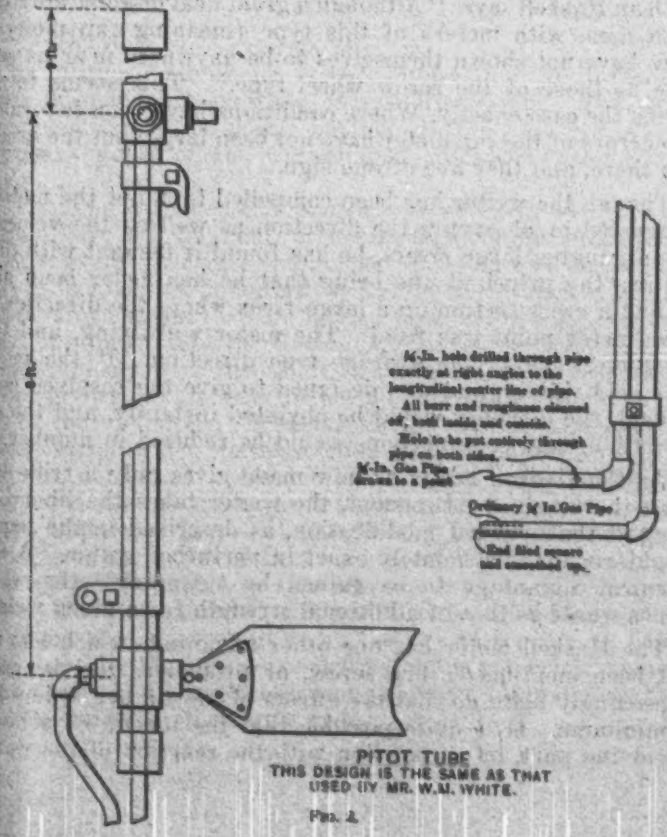
Mr. Price thinks the ratings (Plate XXIII) of the Haskell meter are inaccurate. If any one will take the pains to examine the percentage errors of the various ratings and the wide range of conditions under which these ratings were made, he will feel compelled to admit that the performance of this meter was very consistent throughout. Ratings of this kind are of more practical value than those obtained under restricted conditions, because the former afford an indication

of the degree of accuracy to be expected of the meter when in actual service, while the latter do not.

No doubt the rating line could be adjusted to the observations somewhat better. This rating line was located from a few of the earlier ratings, the later ones being plotted on the diagram subsequently. The change, if made, would be trifling, excepting for low velocities, which were not used.

The idea must not be entertained that the conditions in the Massena tail-races were bad. On the contrary, they were much better than those usually encountered in stream gauging. The flow of the water was parallel to the side-walls, and the meters might as well have been fixed rigidly to the rods, as far as concerned any tendency to swing. The errors of the meters were caused by small eddies and boils such as would certainly have to be dealt with at most gauging stations. The conditions of flow were carefully studied at each of the 84 meter points by using an inverted weather vane. An instrument was invented and used to ascertain the quantity of air in the water at each meter point. This quantity was found to be negligible.

Mr. Price states that a gauging station which has an upstream current should never be used, and one which has divergent currents cannot give accurate results with any method of measurement.



PITOT TUBE
THIS DESIGN IS THE SAME AS THAT USED BY MR. W.M. WHITE.

FIG. 2.

It may be that gauging stations with negative velocities should not be used, but do our current meters give any indication which would lead one to discard such a station when encountered? If the meter is 4 or 5 ft. under water, it cannot be seen; but it goes on recording the velocity just the same, even if the current is directed up stream, and the unsuspecting observer records a considerable positive velocity at the point, whereas it should have been recorded as negative.

As to the matter of divergent currents, the writer believes most fully that the problem may now be solved by using a screw meter held rigidly at right angles to the direction of flow. When the screw is modified, as suggested in the paper, it will increase still further the reliability of the results, even at the best of gauging sections.

Dean Haskell says: "Although a great deal of good work has been done with meters of this type (meaning cup meters), they have not shown themselves to be anywhere near as reliable as those of the screw wheel type." This seems to describe the case exactly. Where conditions have been favorable, the errors of the cup meter have not been large; but the errors are there, and they are of one sign.

Though the writer has been compelled to adopt the method suggested of observing the direction as well as the velocity, when gauging large rivers, he has found it fraught with difficulties, the principal one being that he has never been able to find a cross-section on a large river where the direction at each meter point was fixed. The meter will swing, and this completely masks the average true direction. If the meter was held rigidly, and was designed to give the resolved component, the difficulty would be obviated instantly, and the observations and computations would be reduced in number.

As the Haskell meter as now made gives only a trifle less than the resolved component, the writer takes the liberty to suggest that a slight modification, as described in the paper, might render it absolutely exact in perturbed water. A mechanical advantage to be gained by "cupping" the wheel vanes would be that of additional strength for a given weight.

The Haskell meter has one other advantage which has not yet been mentioned: The screw, or propeller, may be made exceedingly light, so that the effects of inertia are reduced to a minimum. It is quite possible that the inertia of a heavy revolving part, in conjunction with the reaction of the water,

may play an important role in changing the rating when the velocities become variable.

The still-water rating is not satisfactory at present because meters must be used in water which is more or less perturbed. Otherwise, the current meter becomes an instrument of limited use, and demands attention to a complicated system of details. As soon as a meter is produced which will resolve the momentary velocities at a meter point, the still-water rating will apply, even in perturbed water. Dean Haskell is to be congratulated on the fact that his meter almost does this very thing, so that probably only slight modification will be necessary to secure the desired result.

The float and meter comparisons are interesting. Applying the statistical method of summing the velocities in each case, the resulting comparison follows:

Sum of velocities by float	19.67
Sum of velocities by meter	19.74
Difference	0.07

Mr. Miller's discussion is very interesting, as it recounts work of unusual magnitude on the Mississippi. The writer has lived at various points on that river all his life, and remembers much of the Government work of various kinds there.

It is to be regretted that such a keen observer as Mr. Miller should have left the field of current-meter engineering. However, a useful fact once established is bound to live, and thus Mr. Miller its still potentially active in this branch of science.

Mr. Hoyt seems to fear that an impression may be drawn from the paper that the Geological Survey records, based on measurements with the small Price meter, generally involve large errors. This fear is hardly justifiable, as the writer states very definitely, "it seems certain that the correction for a cup meter when run at a good meter station on an open river is not large." On the other hand, it would certainly be on the side of safety to determine the degree of error in every important series of gaugings. One of the best ways to uncover an error of this kind is to run a cup meter and a screw meter in the section simultaneously. If the meters agree, there is no error. If they disagree materially, it will be found that the velocities by the cup meter are excessive, and those by the screw are deficient, the numerical value of such errors by the cup meter being relatively larger than those corresponding by the screw meter.

If any one wishes adminicular evidence as to the truth of this statement, beyond that afforded by the paper, he may refer to the paper, "Current Meter and Weir Discharge Measurements,"* by E. C. Murphy, M. Am. Soc. C. E. In this paper Mr. Murphy has, in the clearest manner, plotted the results of a number of comparisons of discharges by a weir with simultaneous discharges by cup and screw current meters.

In the case of the cup meters, practically all the discharges exceed the corresponding discharges by weir. This is indicated by the fact that practically all the points for the cup meters plot below the axis of abscissas in Fig. 2 of that paper.

In the case of the screw meter, the discharges are generally deficient, as the points generally plot above the axis of abscissas. Moreover, this is the more accurate meter, because the points average much closer to the axis, being in fact within 0.07% of it.

Mr. Hoyt concludes his discussion with several numbered paragraphs. They may be taken up in the same order:

1.—The paper does much more than call attention to the recognized fact that the cup meter is affected by cross-currents. It calls attention to the fact that the effect is productive of errors all on the side of excessive velocity, and that the screw meter is affected in the contrary sense, but to a relatively smaller extent. Though this was discovered by Mr. Miller years ago, it does not seem to have been recognized by anybody else since that time; but it is undoubtedly of the greatest importance to those who wish to improve the present methods of stream gauging.

Before carrying out any experiments at Massena, the writer was of the opinion that screw meters, like cup meters, would always show excessive discharges. This, he thought, would be the case because of the swinging of the meter and the consequent measurement of the thread of a sinuous, rather than of a straight, current. This, however, is incorrect. To prove it, attach a screw meter to the rating boat or rating car. Draw the meter over its course in the usual manner and count the revolutions. Then repeat the process, having all conditions the same as before, except that the meter is oscillated transversely to the direction of motion during its transit of the course. If the rating boat is used, the oscillation may be effected by rocking the boat. In the case of the car, some mechanical device may be used.

Transactions, Am. Soc. C. E., Vol. XLVII, p. 376.

Theoretically, the number of revolutions in the latter case should exceed those in the former case. Practically, the reverse is the case. The side-wash of the current has somewhat more than annulled the effect of increasing the length of the course.

2 and 3.—It is true that the methods used by the writer in making his discharge measurements were described only in a general way. Otherwise, the paper would have become so voluminous that the main facts would have been obscured. It must be remembered that the conclusions of the paper are not derived from a study of current meters *per se*, but are inductions from observations on the behavior of meters while testing turbines.

4.—The large Price meter was adopted as one type of meter to be used in the Massena tests, because the same type had been used by other engineers in the same tail-races several years before, and a comparison was desired. The results of the turbine tests would have been the same had the small Price, or any other cup meter been used instead of the large Price meter, because means were taken to correct the errors due to deviations from the still-water ratings.

5.—The standard adopted by the writer when comparing the cup and screw meters was the true velocity of the water. This appears when discussing Table 5, where it is shown that the cups over-register, on the average, by 5.6%, and the screw under-registers, on the average by 0.93 per cent.

When the Pitot tube and Haskell meter were compared, the Pitot tube was supposed to indicate, on the average, the true velocity. The result of this comparison was that the Haskell meter under-registered by about 0.6 per cent.

Thus there were two different methods of determining the discharge: (*a*) by cup and screw meters corrected through the medium of the boat-rocking tests, and (*b*) by Pitot tube and screw meter comparisons by which corrections were determined to be applied to the metered discharges.

It is worthy of note that these two methods of correcting the discharge, when applied to any given turbine test, give rise to a discrepancy of scarcely 0.3 of 1 per cent.

It is not claimed that rocking the boat is the best means for ascertaining the relative of errors of cup and screw meters. It is claimed that the nature of the case is such that extreme accuracy in this respect is not necessary. This is because the errors to be determined are not relatively large.

If it is feared that this paper is too daring in its conclusions to be credible, it may be well to search for independent verficiation. Such material may be found in Mr. Murphy's extremely valuable paper, "Current Meter and Weir Discharge Measurements," previously quoted.

Though Mr. Murphy gives an interpretation of the results of his experiments, yet he expressly states that he has "avoided in this paper a detailed comparison of results by different meters." Hence it will be permissible to analyze the results for the purpose of such a comparison.

The best method of eliminating accidental errors in comparing such a series of observations is the "statistical" method. In the case at hand, this method is particularly facile because comparable results may be obtained by the simple operation of summation.

In order the better to understand the conditions under which the tests by Mr. Murphy were conducted, it may be stated that they were made in the canal of the Hydraulic Laboratory at Cornell University. The discharge in each test was measured by weir and by two current meters. The two current meters were observed simultaneously in the same discharge section, one starting on the south side and progressing north while the other started on the north side progressing south.

There were twenty-five experiments, each made in the manner described. Ten of these were comparisons between the weir, Haskell meter No. 3, and small Price meter No. 363. Nine were comparisons between the weir, small Price meter No. 351, and small Price meter No. 363. Six were comparisons between the weir, Haskell meter No. 3, and small Price meter No. 351. Moreover, from these experiments may be selected sixteen in which the Haskell meter is compared with the weir, fifteen for Meter No. 351, and nineteen for Meter No. 363.

There are, therefore, six sets of experiments which may be compared statistically. In each case the aggregate discharge by the weir may be compared with the corresponding aggregate, or aggregates, by the meter, or meters, as the case may be. Table 9 gives the comparisons in tabular form.

TABLE 9.—STATISTICAL SUMMARY OF TWENTY-FIVE EXPERIMENTS BY E. C. MURPHY, M. AM. SOC. C. E., IN WHICH THE DISCHARGE OF A CANAL IS MEASURED SIMULTANEOUSLY BY A WEIR AND TWO CURRENT METERS, THE LATTER OPERATED IN THE SAME DISCHARGE SECTION.

Compiled from Table 1, *Transactions, Am. Soc. C. E.*, Vol. XLVII, p. 373.

No. of experiments.	Sum of all the discharges in all experiments, as shown by weir, in cubic feet per second.	SUMS OF THE DISCHARGES IN ALL THE EXPERIMENTS, AS SHOWN BY THE VARIOUS METERS.								
		Screw Type.			Cup Type.					
		Haskell Meter.			Price Meter No. 351.			Price Meter No. 363.		
		Sum, in cubic feet per second.	Error, in cubic feet per second.	Error, Percentage.	Sum, in cubic feet per second.	Error, in cubic feet per second.	Error, Percentage.	Sum, in cubic feet per second.	Error, in cubic feet per second.	Error, Percentage.
10	3 474.78	3 473.99	— 0.79	— 0.02	.....	.....	....	.....	.....	....
15	3 778.67	.....	....	....	3 480.06	+ 65.28	+ 1.94	.....	.....	....
10	4 166.17	.....	.....	.....	.....	.....	....	4 228.92	+ 62.05	+ 1.24
10	2 143.64	2 147.39	+ 3.75	+ 0.18	.....	.....	....	2 164.98	+ 20.55	+ 0.96
6	1 351.14	1 396.60	— 4.54	— 0.34	1 368.86	+ 37.19	+ 2.79	.....	.....	....
9	2 064.58	.....	....	....	2 070.77	+ 25.84	+ 1.39	2 094.01	+ 31.43	+ 1.54

The function of such a summary of aggregates is to eliminate in large measure the unavoidable accidental errors arising during the observations. Thus the remaining errors are each composed of two parts, namely, a large part, which is the net average constant error of the observations, and a small part, which is the net residual of the unequated accidental errors. From the approximate uniformity of the errors of the table, it may be concluded that accidental errors have been practically eliminated, and the computed errors for the sets of observations of greatest weight (the first three sets in the table) are the constant errors due to the meters, or due to deviations from their still-water ratings. Thus the constant error of the Haskel meter is —0.02%, that of the small Price No. 351 is +1.94% and that of the small Price No. 363 is +1.24 per cent. It may be inferred from the plottings by Mr. Murphy, on page 376 of his paper, that the average constant error of No. 351 should exceed that of No. 363. The reason for this is that the discharge by either of the meters

shows an increasing excess over the discharge by the weir with decreasing velocities, and there are relatively more observations of low velocity by Meter No. 351 than by No. 363. Had the reverse been the case, it might have been expected that the constant error of No. 363 would exceed that of No. 351.

It will be seen that the error of the Haskell meter for the ten comparisons with weir and small Price meter No. 363, is +0.18 per cent. This error, though insignificant, would have been negative had it not been for three experiments, Nos. 1-2, 3-4, and 5-6, in which this meter, for some unaccountable reason, gave discharges 4 or 5% greater than the weir. These three observations are plainly discordant, as may be seen by referring to the plottings for the Haskell meter in Fig. 2 of Mr. Murphy's paper. Had the meter run in these three experiments according to the same law as in all the other experiments, the errors for these three experiments would have been about nil. Thus the excess in discharge by the Haskell meter in the three experiments in question is about 25 cu. ft. per sec., as may be seen by consulting Table No. 1 of Mr. Murphy's paper. The aggregate for the weir from the writer's comparison, Table 9, is 3 474.78, and that for the meter would become 3 473.99—25.0=3 448.99. Thus the deficiency in the aggregate for the Haskell meter would be 3 474.78—3 448.99= 25.79. In other words, it is more than probable that the discharges by the Haskell meter are deficient by the slight percentage of 25.8÷3 475=0.75. However, it will not do to correct or reject observations simply because they are discordant.

It follows from the results shown in Table 9 that the cup meters in all cases gave excessive discharges and the Haskell meter gave relatively much smaller errors, the discharges being slightly deficient on the average. Therefore, the following general conclusions may be drawn from the results contained in Mr. Murphy's valuable paper:

(*a*) When a cup meter is run in moderately perturbed* water, it will register a larger number of revolutions per second than a perfect still-water rating would indicate.

(*b*) When a screw meter is run in moderately perturbed water, it will register a smaller number of revolutions per second than a perfect still-water rating would indicate.

*At the bottom of page 374 of Mr. Murphy's paper it is stated that there was a slight agitation of the water during the experiments.

(*c*) In the foregoing sense, a cup meter is affected relatively to a much greater extent than a screw meter.

(*d*) Either type of meter, when run in moderately perturbed water, will give uniform records in equal times, provided these times are sufficiently long, the flow of the water itself being subject to an established regimen.

(*e*) If both types of meter are used simultaneously in moderately perturbed water, the disparity between the discrepant velocities thus determined by the still-water rating may be taken as a basis for correcting the discrepant velocities.

(*f*) If the discharge by the weir be considered correct, the average error of the Haskell meter in Mr. Murphy's experiments was 0.02% on the side of deficiency, with a probability of its being slightly larger, and the average error of the cup meters was in the neighborhood of 1% on the side of excessive discharge.

(*g*) It would seem to follow that current-meter observations based on still-water ratings, without further correction, should be made with great caution. On the other hand, it seems certain that the correction for a cup meter when run at a good meter station on an open river is not large, and the corresponding correction for a screw meter may be negligible.

6.—It cannot be said that the Pitot tube used at Massena was an unrated instrument. It is an exact copy of one which was investigated as "Tube *N*" by Mr. White in the paper already referred to. It has a coefficient equal to unity.

In speaking of the accuracy of Pitot tubes, two distinct reactions must be kept in mind. One is the impulse of the moving water on the dynamic orifice, the other is the reaction of the static pressure and the moving water on the static orifice. If the static orifice is properly designed, the motion of the water, or the dynamic reaction, will have no effect on it; but the motion of the water will exert either suction or a positive pressure on an improperly designed static opening. It is this latter difficulty which has caused most of the uncertainty as to Pitot tubes.

Mr. White's experiments showed, in the most convincing manner, that the coefficients of all dynamic orifices of circular section, be they cylindrical, diverging, or converging, are exactly equal to unity. This was accomplished by towing a boat through the water with a number of different types of circular dynamic orifices attached somewhat in advance of the stem. The water stood at exactly the same level in all the risers, and the total head raised was equal to the sum of the velocity head and static head in each case.

7.—Although the paper does not essay to offer at once a complete remedy for the erratic behavior of current meters in perturbed water, it does point out the interesting fact that a close estimate of the true velocity may be made by using a screw meter of good design. If still greater accuracy is desired, both cup and screw meters may be used, the records being corrected by the observed relative deviations produced in some such manner as the rocking tests described briefly in the paper; or, even better still, the screw meter may be rated by a properly constructed and properly manipulated Pitot tube, under the exact conditions and at the exact point, or points, where the meter is to be used.

8.—The writer has oscillated a number of meters of different types, both longitudinally (up and down stream) and transversely (athwart stream and vertically). In all cases the cups were affected by increments several times as large as the decrements of the screws. This was for violent, as well as moderate, vibrations. It is true that the ratio is variable, values ranging from 3 to 6 having been noted; but, when the error between the cup and screw is not more than 7%, the application of the extreme ratios leads to corrections for the screw meter of only 1¼ and 1 per cent. Thus, an error of 100% in the true value of the ratio makes a difference in the final discharge of only ¼% for the case cited.

This method, of course, is only a practical way of getting an approximate result, but the approximation is shown to be close.

9.—A current meter which cannot be rated with sufficient accuracy from a boat will show even greater discrepancies when run at the average gauging station. The United States Lake Survey has done a great work on the Niagara and St. Lawrence Rivers, and its ratings were frequently made from a boat. The writer knows that screw meters were used extensively on this important work, but does not know whether

cup meters were also used. If the boat ratings had been unsatisfactory, it is certain that that fact would have led to a condemnation of such ratings. Possibly, if cup meters had been used, the boat ratings would have proven unsatisfactory. Of course, a rating made under laboratory conditions will plot almost exactly on a smooth curve; but a rating of a screw meter of good design will be nearly as good, if made from a boat.

It is presumed by the writer that the changes in the method of rating referred to by Mr. Hoyt were such as might be made by placing the weight too close to the wheel, or by running it near the sides, or bottom, of the tank. These are abnormal ratings, of a character which does not affect the question at hand.

10.—It has already been explained that the large Price meter was selected for the tests at Massena for the sake of comparison with the results of a former test in the same tailraces with a meter of this particular type. The writer is of the opinion that the results would have been substantially the same, even if the small Price meter had been substituted for the larger pattern. It must be emphasized that the conditions of discharge for much the greater portion of the gauging section at Massena were as good as those most frequently encountered at a good gauging station. The reliability of these tests cannot be questioned on this account.

The cup meter ran with great fidelity at any given point in the race. Its rating there, relatively to that of the Haskell meter or Pitot tube, was perfectly definite, a fact which does not seem to have been known heretofore. The trouble was not with the cup meter, but with the application of the still-water rating to the case. A raceway of uniform section can certainly be gauged within 1% of the true discharge. This statement is made because any given condition of discharge can be exactly reproduced at the observer's pleasure. This is one of the facts demonstrated at Massena.

11.—The distribution factor used in the statistical method is essentially a form factor. Its value depends on the shape of the solid constructed out of the components of velocity which are normal to the cross-section when these components are erected at their points of application. To every shape a particular value of the distribution factor attaches, but it is not true, conversely, that to every value of the distribution

factor a particular shape must attach. It is only necessary that shapes be equivalent as to discharge in order that two or more shapes may have the same value for their distribution factors. Hence it is not at all improbable that such changes of distribution actually take place at gauging sections without changing the discharge curve or rating table.

The mean velocity in the cross-section is the quotient obtained by dividing the total discharge by the area of the cross-section. The statistical method relies on this definition. In the turbine tests at Massena, the value of the distribution factor was ascertained by drawing the familiar contours of equal velocity over the cross-section of the race. The volume under these contours was computed, and, when expressed in proper units, was numerically equal to the discharge. This discharge was then divided by the area in order to ascertain the mean velocity.

By definition, the distribution factor is the ratio of the above determined mean velocity to the sum of the velocities recorded at the 42 meter points in the race. By actually computing this ratio, in the foregoing manner, for several of the turbine tests where the conditions were substantially the same, it was found that the value of the ratio—that is, of the distribution factor—was constant for given conditions. Consequently, it follows that the mean velocity in the tail-race may be ascertained simply by multiplying the sum of the observed velocities by the proper value of the distribution factor.

Though a somewhat different procedure was adopted in the Southern work, it was clearly proven that the distribution factor is a definite function of the gauge height, or stage of the river, which, when once reduced to a curve, may thereafter be used as the quickest possible means of ascertaining the mean velocity in the gauging section. This is accomplished simply by multiplying the sum of the velocities at a given set of meter points by the corresponding value of the distribution factor, as read from its locus.

In short, it has been demonstrated by these experiments that, in current-meter work, and discharge gauging in general, one may deal with aggregates of velocity area, and discharge, instead of individual values, with a gain in accuracy, time, labor, and satisfaction, to be realized in no other way.

Take, for example, the case of an observer who has just hurried to a gauging station to measure a discharge at a particular stage of the stream. He drops his meter at two or three dozen permanently established meter points (supposing the river is, say, 250 ft. wide), adds up all his velocities, compares the sum with his statistical velocity curve, finds the sum correct, and then multiplies it by a factor taken from a curve, the product being the discharge. The whole work may be done within an hour or two. Moreover, the observer knows his work is correct, because his velocity observations are checked.

12.—It is very certain that the Geological Survey has done excellent work in studying velocity curves and in formulating therefrom a few simple laws which govern the discharge of rivers. Much of this work is due to Mr. Hoyt with whose name is linked some of the most valuable hydraulic investigations.

For the most part, the writer's studies have been connected with shallow turbulent rivers, as he is frequently compelled to examine streams of this class with regard to the character of their flow. It may be of interest to know that he has arrived at two conclusions connected therewith. They are:

(*a*) A shallow turbulent stream may be gauged satisfactorily with a screw meter, or, better still, with a cup and a screw meter simultaneously.

(*b*) The proper point in a shallow turbulent section at which to take the meter readings is at mid-depth, otherwise the meter is too near the surface or too near the bottom to admit of accuracy.

Like Mr. Hoyt, the writer has summed up the measured discharges of two or more tributaries to find a good check on the discharge of the main stream. This does not prove, however, as a necessary conclusion, that the work at any of the stations is correct, as all may be, and sometimes are, affected by the same constant error.

In reply to Mr. Staniford: The writer has had only a limited experience with the current meter in salt water, in the form of a ship's log. This instrument was of the screw type, the runner being very similar to that of the Haskell meter. With care, such an instrument will give distances, and, there-

fore, velocities, well within 2%, even when the sea is agitated, assuming, of course, that there is no current or surface drift.

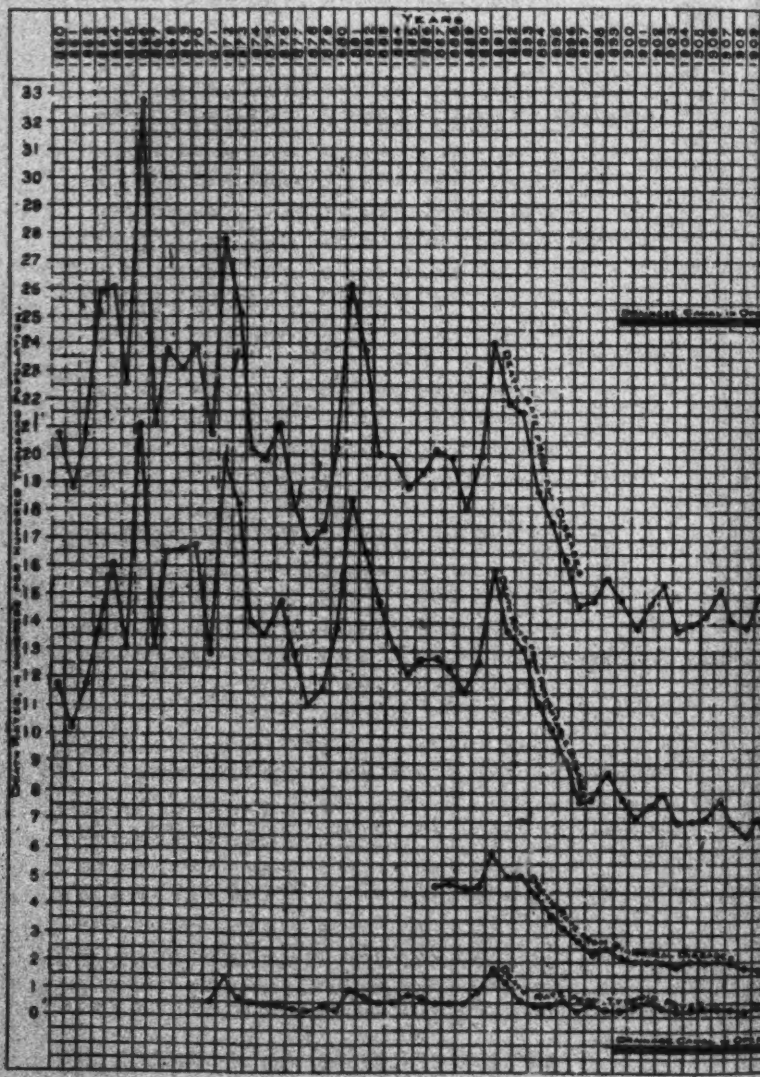
The Haskell meter was designed by Dean Haskell when he was working in salt water, and is adapted for use in both salt and fresh water. These meters have been used in coast harbors by officers of the U. S. Engineer Corps, and the Coast and Geodetic Survey; these officers would undoubtedly be able to state how fresh- and salt-water ratings compare.

ADAMS EXHIBIT ONE.

2—CHICAGO.

Death rates per 100,000 of population.

Years.	All Causes.	Typhoid Fever.	Diarrheal Diseases.	Tuberculosis.	Pneumonia.	Bronchitis.	Influenza.	Diphtheria and Croup.	Scarlet Fever.	Tuberculosis of the Lungs.	Measles.	Whooping Cough.	Small-pox.	Bright's Disease.	Heart Disease.	Cancer.	Violence.	Tuberculosis other than Pulmonary.	Children under 5 years.
1887	2027	50.3	477.6	202.6	132.6	99.2	.....	184.9	25.0	180.7	44.9	13.9	.3	42.1	72.2	39.6	126.8	22.0	996
1888	1965	46.7	487.2	201.3	137.7	102.5	.....	161.6	22.9	182.1	16.8	22.8	.....	41.1	77.1	45.0	110.5	19.2	939
1889	1812	48.4	465.6	181.0	125.0	87.3	0.1	161.4	19.8	164.9	21.8	10.3	.2	39.9	71.0	40.5	104.4	16.0	878
1890	1967	91.6	471.5	201.9	188.5	108.1	10.2	114.7	17.5	182.8	6.1	18.3	.....	46.3	74.2	41.9	130.4	19.2	899
1891	2416	173.8	585.3	208.9	251.8	130.1	1.7	118.2	43.4	184.5	23.1	16.9	.....	51.7	80.9	47.4	128.8	24.4	1097
1892	2185	124.1	508.6	198.6	190.8	108.6	8.6	129.0	31.8	182.3	15.4	13.7	.2	50.8	88.2	44.9	138.4	16.3	972
1893	2161	63.5	512.6	211.2	196.1	111.4	7.0	117.1	26.3	185.5	18.7	16.8	1.8	60.1	88.3	48.6	151.7	22.7	986
1894	1826	37.5	445.5	191.0	116.1	90.5	3.9	106.4	14.5	167.4	13.9	16.0	78.9	52.0	79.3	48.8	118.4	23.5	842
1895	1772	37.9	372.7	180.2	172.6	82.9	12.1	120.1	5.6	159.1	11.4	8.9	11.5	51.3	99.8	49.9	106.3	21.1	765
1896	1629	53.6	357.2	186.8	150.0	81.6	1.2	76.2	3.8	162.4	5.1	13.1	.....	57.3	90.3	51.4	103.7	24.4	680
1897	1463	29.8	278.2	172.6	144.3	68.8	1.0	51.9	5.4	146.4	9.3	10.7	.....	62.8	91.6	49.8	99.7	28.3	574
1898	1404	40.8	241.5	181.7	169.1	63.9	18.0	43.7	4.3	155.2	3.5	13.4	.....	67.5	89.8	50.6	97.4	26.5	523
1899	1503	27.2	253.5	178.9	211.4	62.3	19.1	55.4	32.9	154.7	10.3	4.7	.1	72.6	91.7	54.7	97.5	24.2	546
1900	1468	19.8	216.2	173.9	199.5	66.1	9.4	49.5	13.3	153.0	11.4	16.8	.1	65.7	111.4	56.2	97.3	20.8	487
1901	1397	29.1	211.3	164.0	178.5	49.4	11.5	29.4	9.4	142.4	9.0	11.8	.2	57.9	111.1	57.2	99.9	21.6	428
1902	1473	44.5	201.0	165.4	190.6	54.3	6.6	34.8	24.7	141.9	6.8	14.8	.3	60.8	116.5	59.6	104.9	23.5	446
1903	1562	31.8	194.6	182.5	250.1	54.3	9.0	34.4	16.0	135.0	14.9	14.6	2.5	81.9	113.0	57.4	130.9	27.5	447
1904	1410	19.6	177.7	186.5	217.8	44.0	6.0	21.5	7.5	164.8	2.5	5.9	1.5	97.3	107.5	59.2	106.0	21.7	371
1905	1413	16.9	192.5	188.8	184.1	43.5	7.9	22.2	4.1	164.6	11.9	18.4	3.1	103.5	108.3	61.1	108.3	24.2	438
1906	1453	18.5	197.0	192.0	202.5	36.3	6.0	27.7	24.7	161.3	6.4	8.4	.....	106.5	109.8	66.5	111.6	20.7	440
1907	1572	18.2	195.4	197.2	232.1	38.4	11.6	27.1	35.1	171.5	12.8	12.0	.03	121.9	113.2	75.1	121.6	25.7	402
1908	1449	15.8	202.3	186.7	167.4	37.6	15.9	26.5	19.6	163.0	8.1	6.4	.....	102.0	128.1	74.9	118.1	23.7	459
1909	1458	12.6	171.1	181.0	219.6	6.8	8.7	31.7	17.2	155.9	7.7	6.5	.....	105.9	147.4	76.7	126.5	25.1	436
1910	1514	13.7	177.2	178.0	240.8	7.8	6.6	37.4	18.4	153.3	8.7	7.9	.03	113.9	151.4	82.3	116.2	24.7	461
1911	1455	10.9	147.0	166.0	219.6	4.0	5.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	409
1912	1492	7.5	149.7	163.5	220.4	4.7	2.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	436



ADAM'S EXHIBIT 2.

ADAMS' EXHIBIT 3

6.

COURSE OF THE DEATH RATES FROM IMPURE WATER DISEASES AND IMPURE AIR DISEASES: CHICAGO, 1887-1912.

COMPARISON OF TWO THIRTEEN-YEAR PERIODS.

Death-Rates per 100,000 Population.

Year	IMPURE AIR DISEASES (Tuberculosis. Influenza.) (Pneumonia. Bronchitis.) Total	IMPURE WATER DISEASES Typhoid and Diarrheal Diseases.
1887	434.5	527.6
1888	441.5	533.9
1889	393.4	514.0
1890	508.7	563.1
1891	593.1	758.1
1892	515.6	623.7
1893	525.7	566.1
1894	401.5	483.0
1895	447.8	410.6
1896	419.6	389.8
1897	386.8	307.5
1898	422.7	282.3
1899	471.8	280.7
1900	447.8	236.0
1901	403.4	240.4
1902	416.8	245.5
1903	495.9	226.4
1904	454.3	197.3
1905	424.3	209.4
1906	436.8	215.5
1907	479.4	213.6
1908	407.6	218.1
1909	416.1	183.7
1910	433.2	190.9
1911	394.8	157.9
1912	391.4	157.2
Average Rate.		Average Rate.
1887-1899	458.7	480.7
1900-1912	430.9	207.1
Decrease	27.8	237.6
Per Cent Decrease	6.1%	56.9%

ADAMS' EXHIBIT 4

Distribution of Deaths from Typhoid Fever, by sex and age.
Chicago, 1912.

Age	Males	Per Cent of all Deaths of Males	Females	Per Cent of all Deaths of Females	Both Males and Females	Per Cent of all Deaths
1- 5	5	4.27%	4	6.8	9	5.1
5-10	5	4.27	7	11.9	12	6.8
10-20	18	15.4	13	22.0	31	17.6
20-30	42	35.9	20	33.9	62	35.2
30-40	22	18.8	10	16.9	32	18.2
40-50	18	15.4	2	3.4	20	11.4
50-60	5	4.27	1	1.7	6	3.4
60-70	2	1.7	1	1.7	3	1.7
70-80			1	1.7	1	.6
All ages	117	100.0	59	100.0	176	100.0

Males constitute 66.5% of all deaths, females, 33.5%.
(Data taken from the records of the Chicago Department of Health.)

ADAMS' EXHIBIT 5.

II.

DECREASE IN VARIOUS DEATH-RATES SINCE THE DRAINAGE CANAL WENT INTO OPERATION.

Comparison of Two Thirteen Year Periods: (1887-1899) and (1900-1912)
Death-rates per 100,000 Population.

CAUSE	Decrease in Death-rate (1887-1899) (1900-1912)	Per Cent Decrease (1887-1899) (1900-1912)	Number of Deaths Prevented from cause named for every death Prevented from Typhoid.
All Causes	398	21.3	9.3
Preventable Diseases	418	36.9	9.8
Impure Water Diseases (as recognized by Chicago Dept. of Health)	274	56.9	6.4
Impure Water Diseases (as recognized by Sedgwick and MacNutt)	‡290	31.8	6.8
Diarrheal Diseases	231	55.2	5.4
Typhoid Fever	42.7	68.2	...

‡1887-1899 compared with 1900-1912.

ADAMS EXHIBIT 6.

ADAMS' EXHIBIT 7.
(Public—No. 92.)

An act to facilitate the collection of commercial statistics required by section 2 of the river and harbor appropriation acts of eighteen hundred and sixty-six and eighteen hundred and sixty-seven.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That owners, agents, masters and clerks of vessels arriving and departing from localities where works of river and harbor improvements are carried on shall furnish, on application of the persons in local charge of the works, a comprehensive statement of vessels, passengers, freight and tonnage.

Sec. 2. That every person or persons offending against the provisions of this act shall, for each and every offense, be liable to a fine of one hundred dollars, or imprisonment not exceeding two months, to be enforced in any district court in the United States within whose territorial jurisdiction such offense may have been committed.

Approved February 21st, 1891.

Trip No. _____

Statement of Traffic
Passing Through
St. Mary's Falls Canal

_____ 190____

From _____

To _____

Bound Down
(East)

Name and Class of Vessel _____

Draft of Water _____ feet _____ inches

Copper, tons _____

Grain, bushels (Corn, Oats, Rye, Barley, Flax Seed) _____

_____

Building Stone, tons _____

Flour bbls. _____

Iron Ore, tons _____

Iron, Pig, tons _____

Lumber, M ft. _____

Silver Ore, tons _____

Wheat, bushels _____

Unclassified Freight, tons _____

Total Cargo, tons _____

Passengers, number _____

_____

Clerk Master

N. B.—(All tons are "net" tons of 2,000 pounds except where otherwise specified.) Detroit March, 1905—30,000.

E31(b)

ADAMS' EXHIBIT 8.
(Public—No. 92.)

An act to facilitate the collection of commercial statistics required by section 2 of the river and harbor appropriation acts of eighteen hundred and sixty-six and eighteen hundred and sixty-seven.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That owners, agents, masters and clerks of vessels arriving and departing from localities where works of river and harbor improvements are carried on shall furnish, on application of the persons in local charge of the works, a comprehensive statement of vessels, passengers, freight and tonnage.

Sec. 2. That every person or persons offending against the provisions of this act shall, for each and every offense, be liable to a fine of one hundred dollars, or imprisonment not exceeding two months, to be enforced in any district court in the United States within whose territorial jurisdiction such offense may have been committed.

Approved February 21st, 1891.

Trip No. _____

Statement of Traffic
Passing Through
St. Mary's Falls Canal

_____ 191__

From _____

To _____

Bound Up
(West)

Name and Class of Vessel _____

Draft of Water _____ feet _____ inches

Coal, tons Soft _____ Hard _____

Grain, bushels (Corn, Oats, Seeds, Cut Feed) _____

Flour, bbls. _____

Manufactured Iron, tons _____

Salt, bbls. _____

Unclassified Freight, tons _____

Total Cargo, tons _____

Passengers, number _____

_____ Clerk _____ Master

N. B.—All tons are "net" tons of 2,000 pounds, except where otherwise specified.

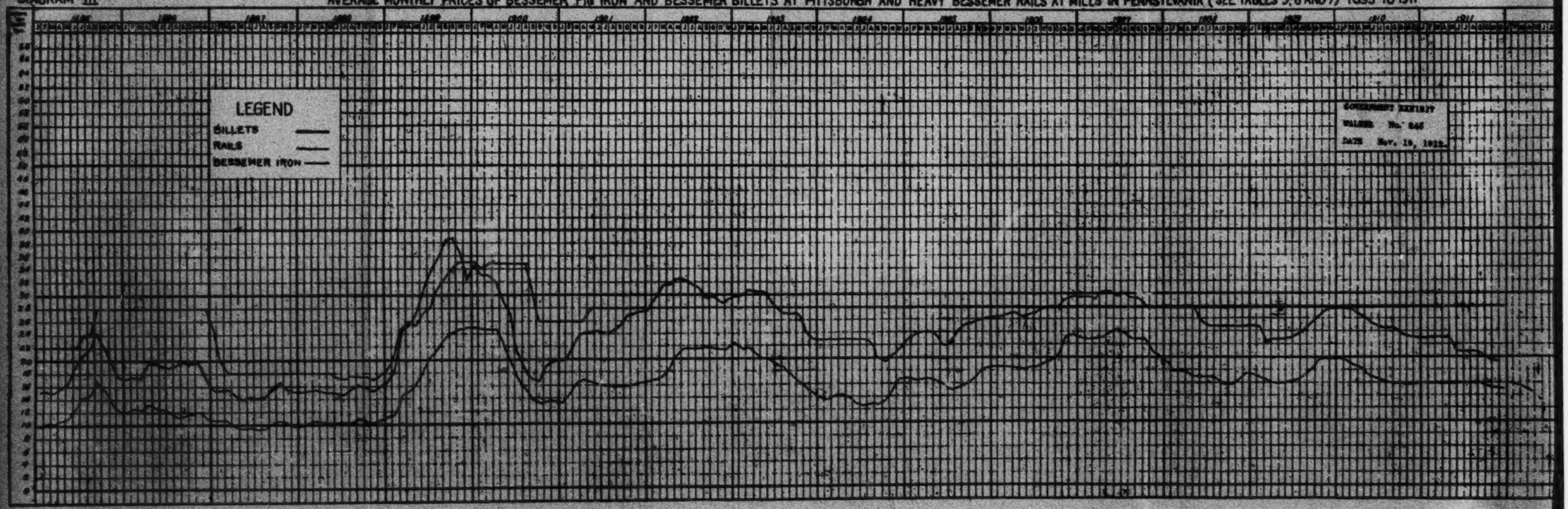
Detroit, April 12, 20,000.

Adams Exhibit 9.

Adams' Exhibit

DIAGRAM III

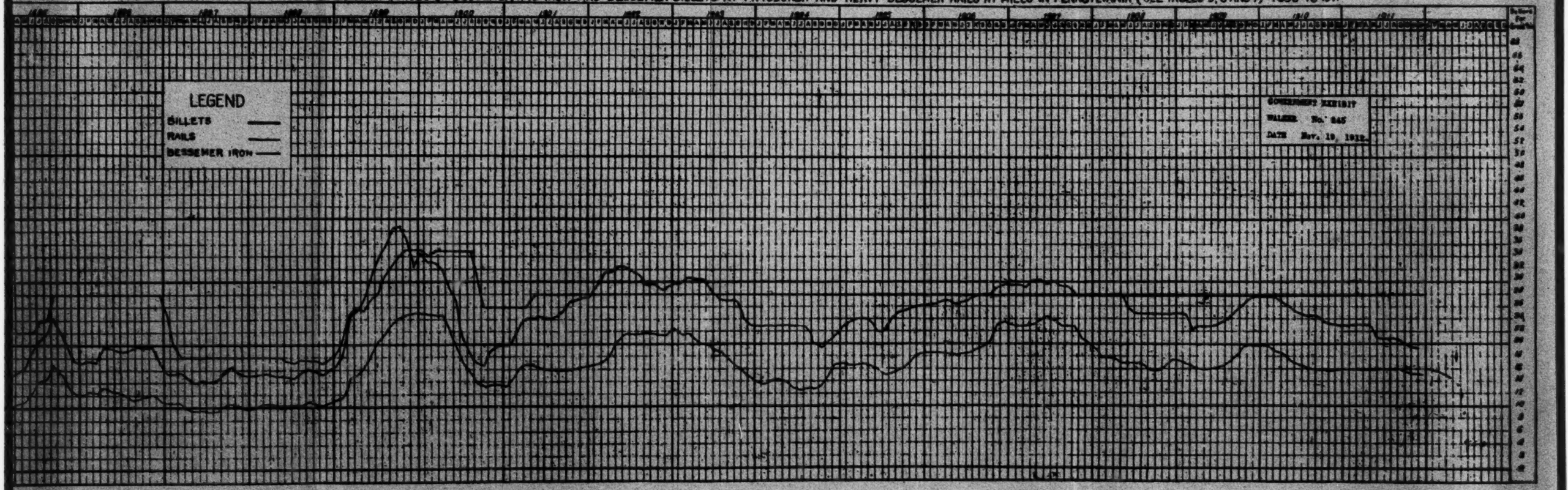
AVERAGE MONTHLY PRICES OF BESSEMER PIG IRON AND BESSEMER BILLETS AT PITTSBURGH AND HEAVY BESSEMER RAILS AT MILLS IN PENNSYLVANIA (SEE TABLES 5, 6 AND 7) 1895 TO 1911



Adams' Exhibit 9

AM III

AVERAGE MONTHLY PRICES OF BESSEMER PIG IRON AND BESSEMER BILLETS AT PITTSBURGH AND HEAVY BESSEMER RAILS AT MILLS IN PENNSYLVANIA (SEE TABLES 5, 6 AND 7) 1895 TO 1911



ADAMS' EXHIBIT 10. 1675
Government Exhibit Walker No. 268
Date, Nov. 20, 1912

TABLE 52. Average Price of Heavy Steel Rails in England and in the United States, 1895 to 1911, by months (Dollars per Gross Ton).

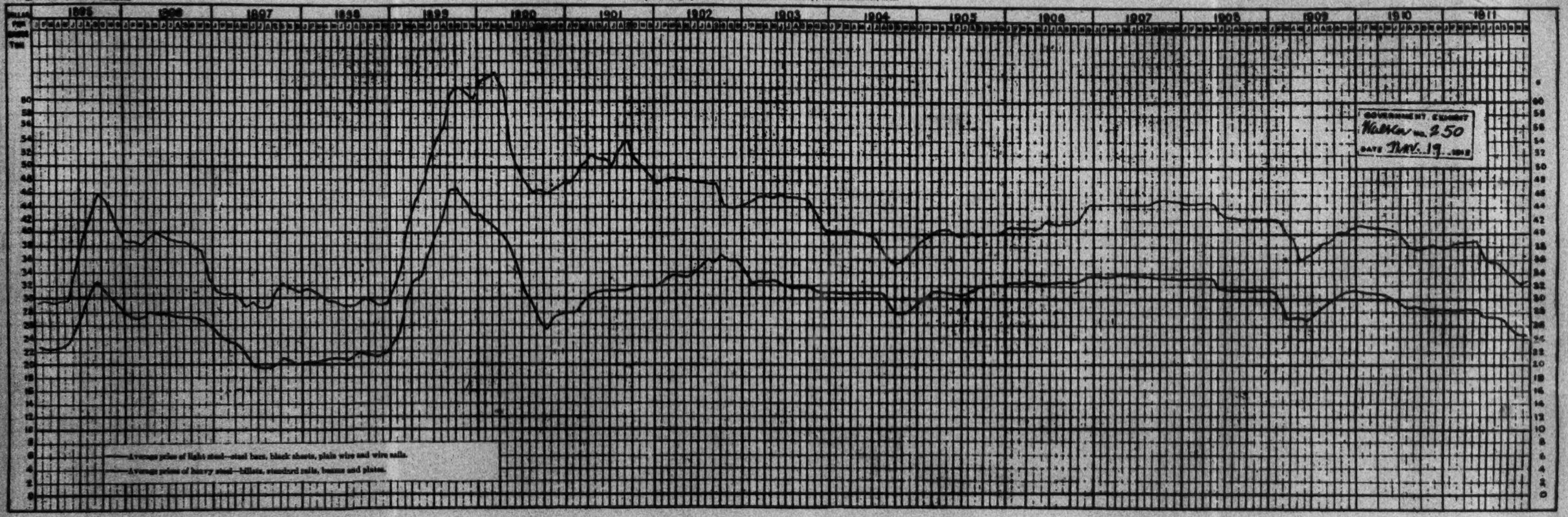
	1895		1896		1897		1898		1899		1900	
	England	United States	England	United States	England	United States	England	United States	England	United States	England	United States
January	17.18	22.00	23.11	28.00	22.38	25.00	21.90	18.00	22.96	18.50	34.06	35.00
February	17.03	22.00	23.11	28.00	22.50	20.00	21.90	18.00	23.11	20.25	34.37	34.20
March	17.27	22.00	23.11	28.00	22.05	18.00	21.90	18.00	23.23	24.80	36.01	35.00
April	17.64	22.00	22.50	28.00	21.90	18.00	21.90	18.00	24.48	25.75	37.40	35.00
May	17.64	22.00	22.14	28.00	21.90	18.00	21.90	18.00	24.94	25.20	37.71	35.00
June	17.64	22.00	21.90	28.00	21.90	18.00	21.90	17.50	25.30	27.25	37.10	35.00
July	17.64	24.00	21.90	28.00	21.90	18.00	22.14	17.00	30.26	28.25	36.50	35.00
August	18.25	24.00	21.90	28.00	21.90	18.00	22.50	17.50	30.41	31.00	35.16	35.00
September	19.31	28.00	21.90	28.00	21.90	18.00	22.50	17.50	32.36	32.50	34.06	30.25
October	21.13	28.00	21.90	28.00	21.90	18.00	22.50	17.50	32.85	34.00	34.06	26.00
November	22.87	28.00	21.90	28.00	21.90	18.00	22.50	17.50	33.76	35.00	30.66	26.00
December	23.11	28.00	21.90	28.00	21.90	18.00	22.50	17.50	34.06	35.00	28.89	26.00
Average	18.89	24.33	22.27	28.00	22.00	18.75	22.17	17.63	28.14	28.13	34.67	32.29

	1901		1902		1903		1904		1905		1906	
	England	United States	England	United States	England	United States	England	United States	England	United States	England	United States
January	28.50	26.00	26.28	28.00	26.76	28.00	22.87	28.00	21.90	28.00	29.35	28.00
February	27.67	26.00	24.63	28.00	26.76	28.00	21.90	28.00	23.72	28.00	30.11	28.00
March	25.79	26.00	25.70	28.00	26.76	28.00	21.90	28.00	24.45	28.00	30.41	28.00
April	25.55	26.00	26.76	28.00	26.76	28.00	21.90	28.00	25.55	28.00	30.41	28.00
May	25.06	28.00	26.76	28.00	26.76	28.00	21.90	28.00	25.55	28.00	30.87	28.00
June	25.24	28.00	26.76	28.00	26.76	28.00	21.90	28.00	25.55	28.00	31.02	28.00
July	26.76	28.00	26.76	28.00	26.76	28.00	21.90	28.00	25.55	28.00	31.02	28.00
August	26.76	28.00	26.76	28.00	25.55	28.00	21.90	28.00	25.55	28.00	31.02	28.00
September	26.76	28.00	26.76	28.00	24.33	28.00	21.90	28.00	25.55	28.00	30.72	28.00
October	26.76	28.00	26.76	28.00	24.33	28.00	21.90	28.00	25.55	28.00	30.41	28.00
November	26.76	28.00	26.76	28.00	24.33	28.00	21.90	28.00	28.13	28.00	30.53	28.00
December	26.76	28.00	26.76	28.00	24.33	28.00	21.90	28.00	28.95	28.00	31.63	28.00
Average	26.54	27.33	26.45	28.00	25.85	28.00	21.98	28.00	25.50	28.00	30.63	28.00

	1907		1908		1909		1910		1911	
	England	United States	England	United States	England	United States	England	United States	England	United States
January	32.08	28.00	29.80	28.00	26.15	28.00	25.55	28.00	27.52	28.00
February	32.69	28.00	29.20	28.00	25.55	28.00	26.00	28.00	27.98	28.00
March	32.85	28.00	29.20	28.00	25.55	28.00	26.15	28.00	27.86	28.00
April	32.85	28.00	28.50	28.00	25.55	28.00	26.28	28.00	27.37	28.00
May	32.85	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
June	32.85	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
July	32.85	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
August	32.85	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
September	32.08	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
October	31.63	28.00	27.98	28.00	25.55	28.00	26.76	28.00	27.37	28.00
November	30.66	28.00	27.67	28.00	25.55	28.00	26.76	28.00	27.37	28.00
December	30.41	28.00	26.76	28.00	25.55	28.00	26.76	28.00	27.37	28.00
Average	32.22	28.00	28.26	28.00	25.60	28.00	26.51	28.00	27.47	28.00

DIAGRAM VIII

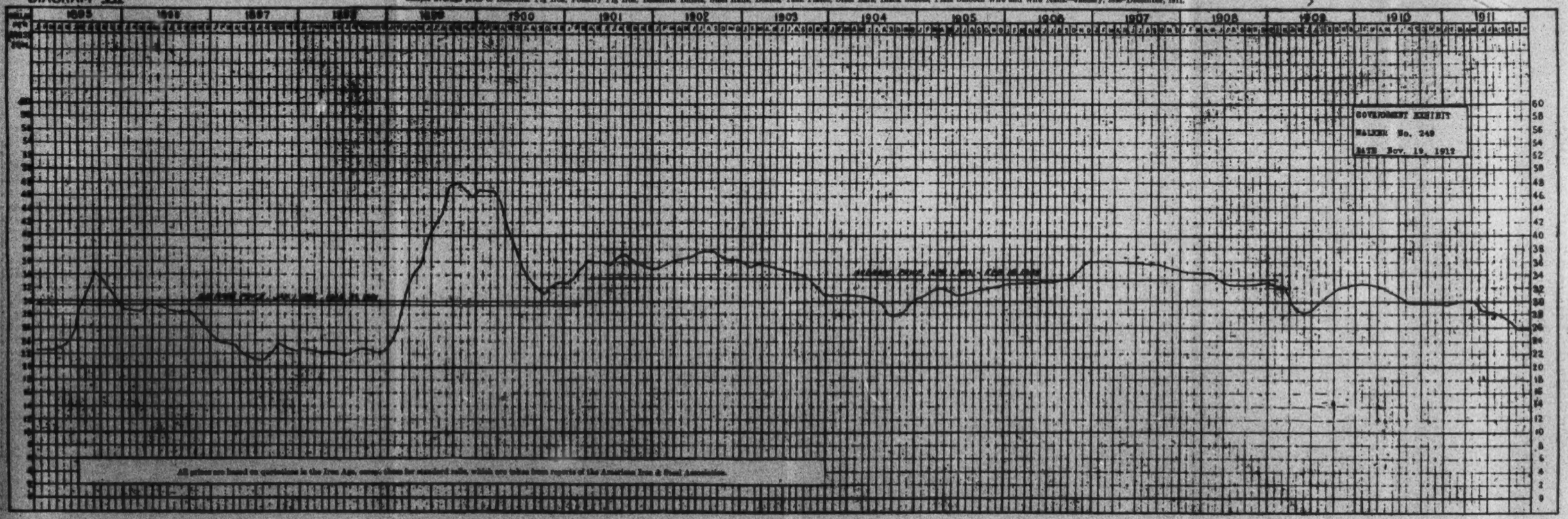
Simple average prices of Steel Products.—January, 1895-December, 1911.



Adam's Exhibit 12.

DIAGRAM VII

Simple average price of Bessemer Pig Iron, Foundry Pig Iron, Bessemer Billets, Steel Rails, Beams, Tank Plates, Steel Bars, Black Sheets, Plain Smooth Wire and Wire Nails.—January, 1895–December, 1911.



ADAMS' EXHIBIT 13.

19

Loss that would be sustained by the City of Chicago and dependent populations were the present facilities for obtaining an adequate supply of pure water impaired or destroyed, based upon a comparative study of health statistics of the city for 13 years before and 13 years after the opening of the Chicago Drainage Canal.

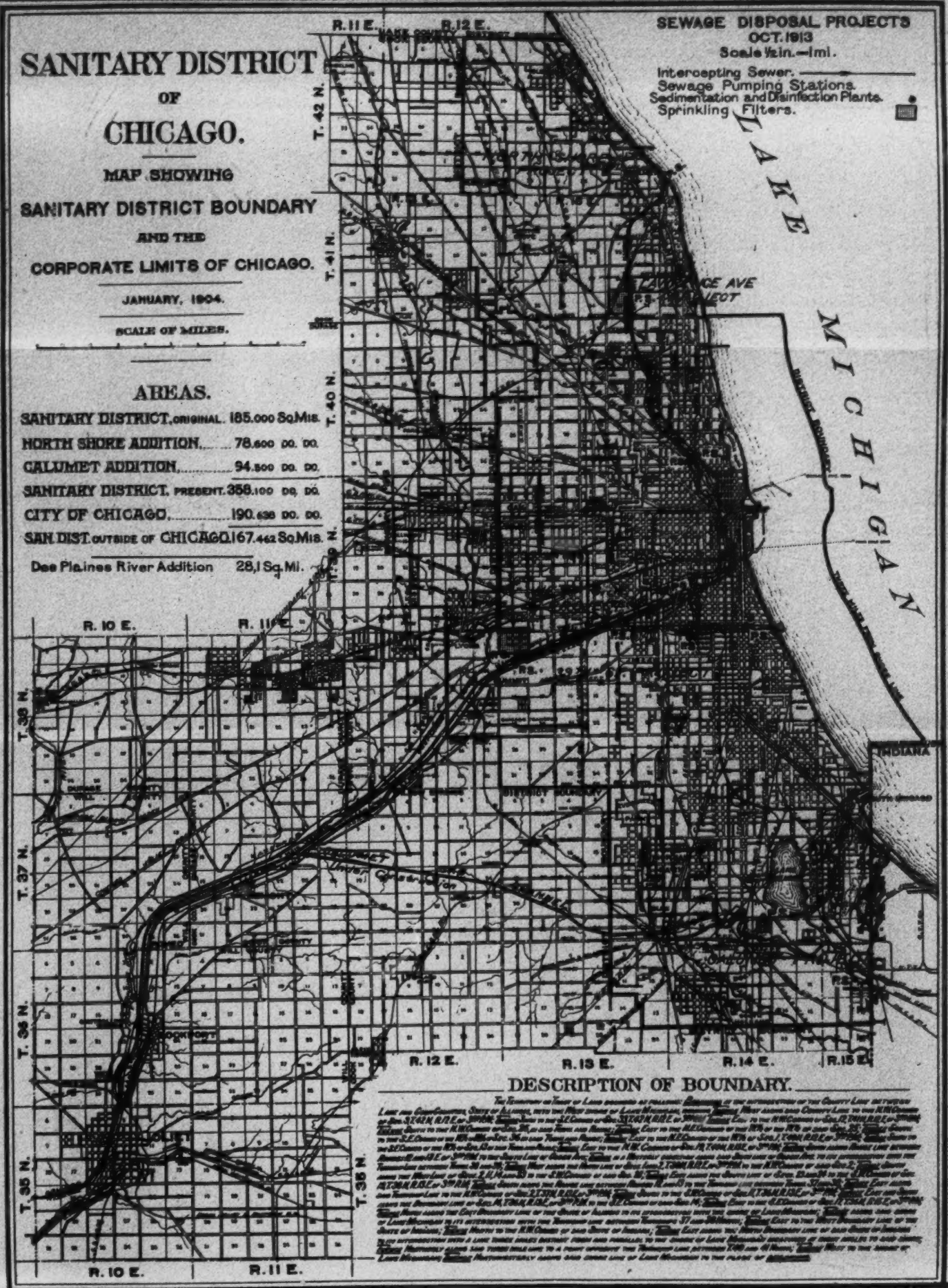
Per Annum.

Per 100,000 of the Population.

Kinds of Loss.	From Increase in Typhoid Fever	From Increase in Other Diseases
I. By Loss of Contributions to Maintenance:		
a. Through premature death of male workers, 83% of 28.39x36x300	$254,488	$636,220
b. Through sickness, 83% of (483x10) + (28.39x2) + 52x300	23,400	23,400
II. By Decrease in Capital Building:		
a. Through premature death, 42.7x 36x40	28,256	70,640
b. Through sickness (726x10) + 52x40	5,581	5,581
III. By Unnecessary Dissipation of Resources: 483x58.41	42,405	42,405
	$354,130	$778,246

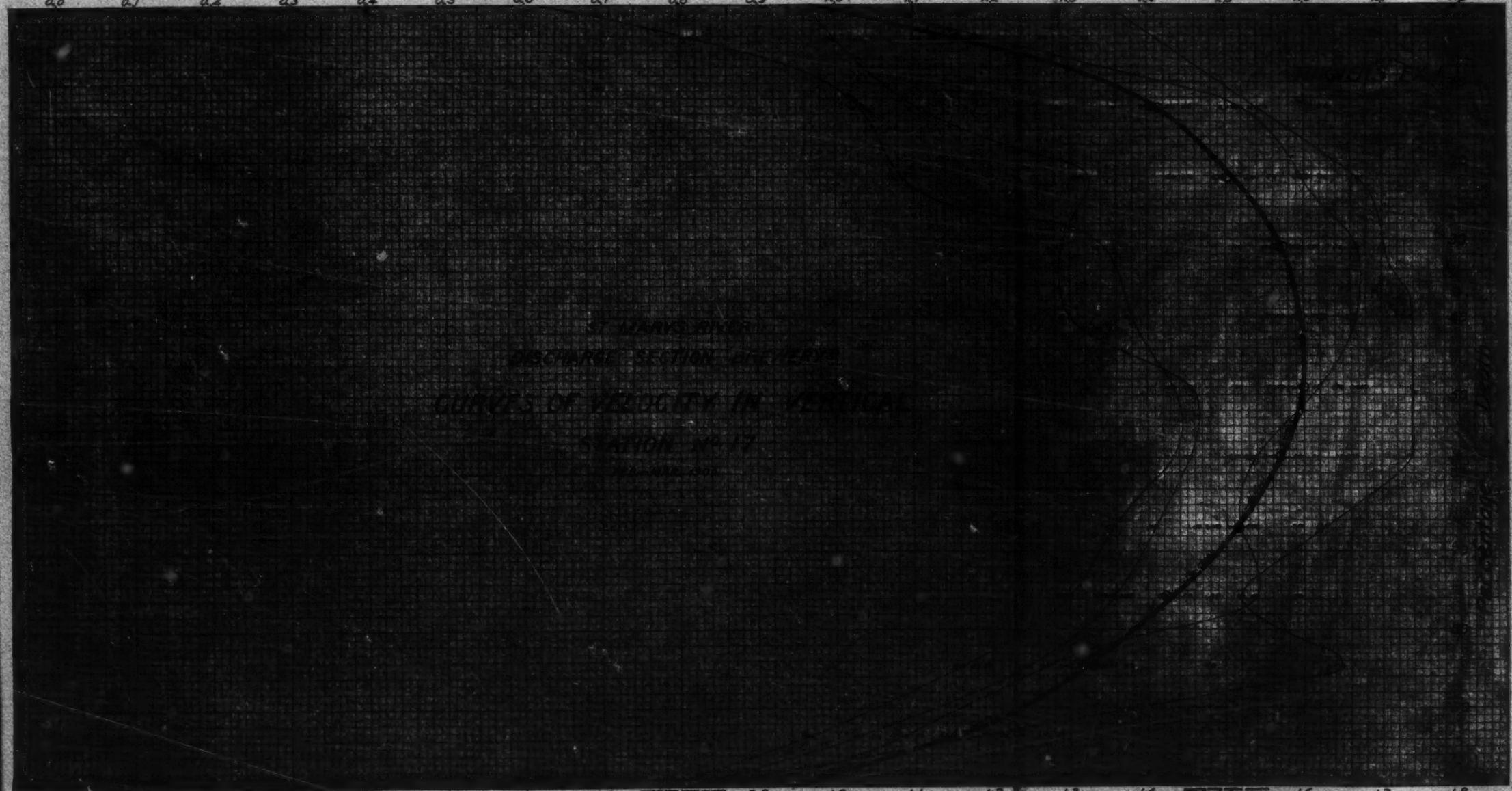
$354,130x23 = $8,144,900.

$778,246x23 = $17,899,658, which is the annual loss to the City of Chicago.


SANITARY DISTRICT
OF
CHICAGO.
MAP SHOWING
SANITARY DISTRICT BOUNDARY
AND THE
CORPORATE LIMITS OF CHICAGO.
JANUARY, 1904.
SCALE OF MILES.
AREAS.
SANITARY DISTRICT, ORIGINAL. 185.000 Sq. Mls.
NORTH SHORE ADDITION, 78.600 DO. DO.
CALUMET ADDITION, 94.500 DO. DO.
SANITARY DISTRICT, PRESENT. 358.100 DO. DO.
CITY OF CHICAGO, 190.638 DO. DO.
SAN. DIST. OUTSIDE OF CHICAGO. 167.462 Sq. Mls.
Des Plaines River Addition 28.1 Sq. Mi.
SEWAGE DISPOSAL PROJECTS
OCT. 1913
Scale 1/2 in. = 1 mi.
Intercepting Sewer.
Sewage Pumping Stations.
Sedimentation and Disinfection Plants.
Sprinkling Filters.
LAKE MICHIGAN
INDIANA
R. 10 E.
R. 11 E.
R. 12 E.
R. 13 E.
R. 14 E.
R. 15 E.
T. 42 N.
T. 41 N.
T. 40 N.
T. 39 N.
T. 38 N.
T. 37 N.
T. 36 N.
DESCRIPTION OF BOUNDARY.

Velocity in Feet per Second

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8



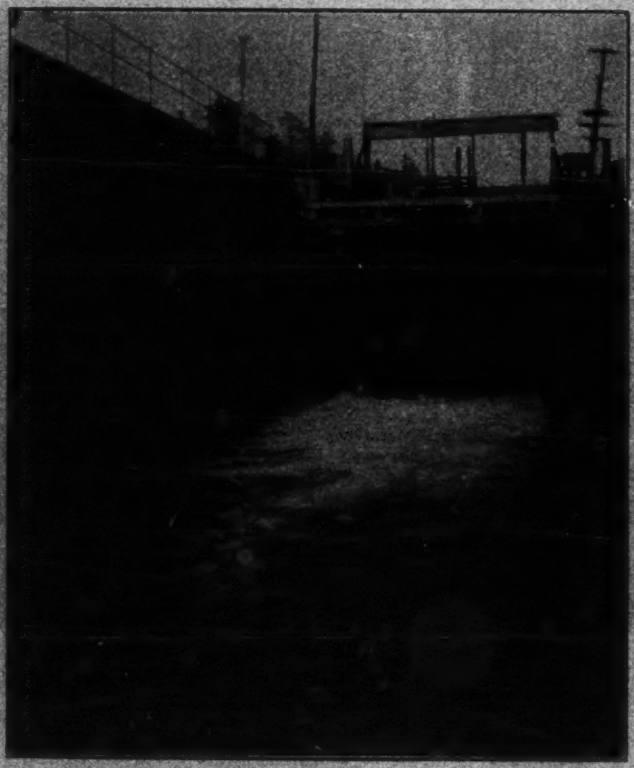
0.0 0.2 0.3 0.4 0.5 0.6 0.7 0.9 1.0 1.1 1.2 1.3 1.4 1.6 1.7 1.8

Velocity in Feet per Second

SCHODER EXHIBIT 1.
Dec. 13, 1913.

SCHODER EXHIBIT 2.

Dec. 13, 1913.

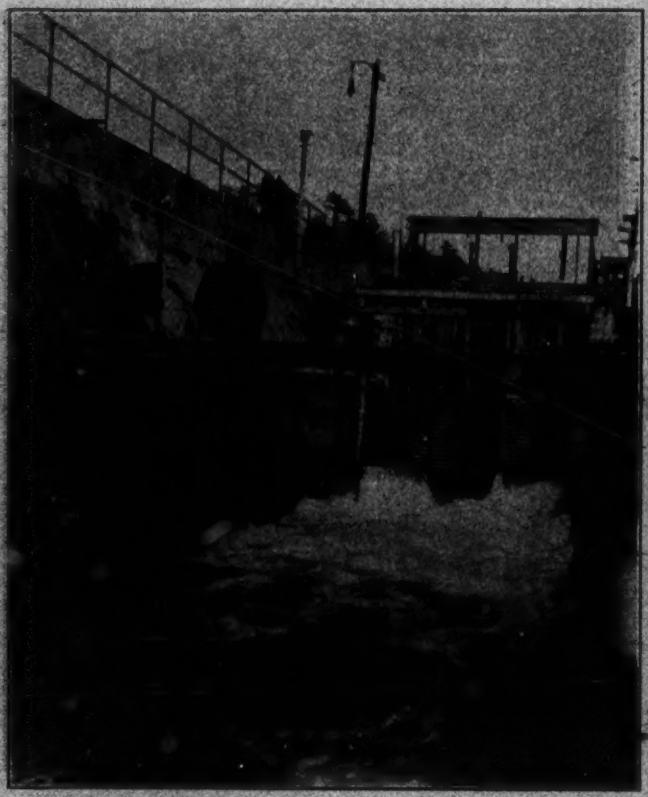


SCHODER EXHIBIT 3.

Dec. 13, 1913.

SCHODER EXHIBIT 4.

Dec. 13, 1913.



SCHODER EXHIBIT 5.

Dec. 13, 1913.

SCHODER EXHIBIT 6.
Dec. 13, 1913.

SCHODER EXHIBIT 7.

Dec. 13, 1913.

SCHODER EXHIBIT 8.
Dec. 13, 1913.

SCHODER EXHIBIT 9.

Dec. 13, 1913.

SCHODER EXHIBIT 10.
Dec. 13, 1913.

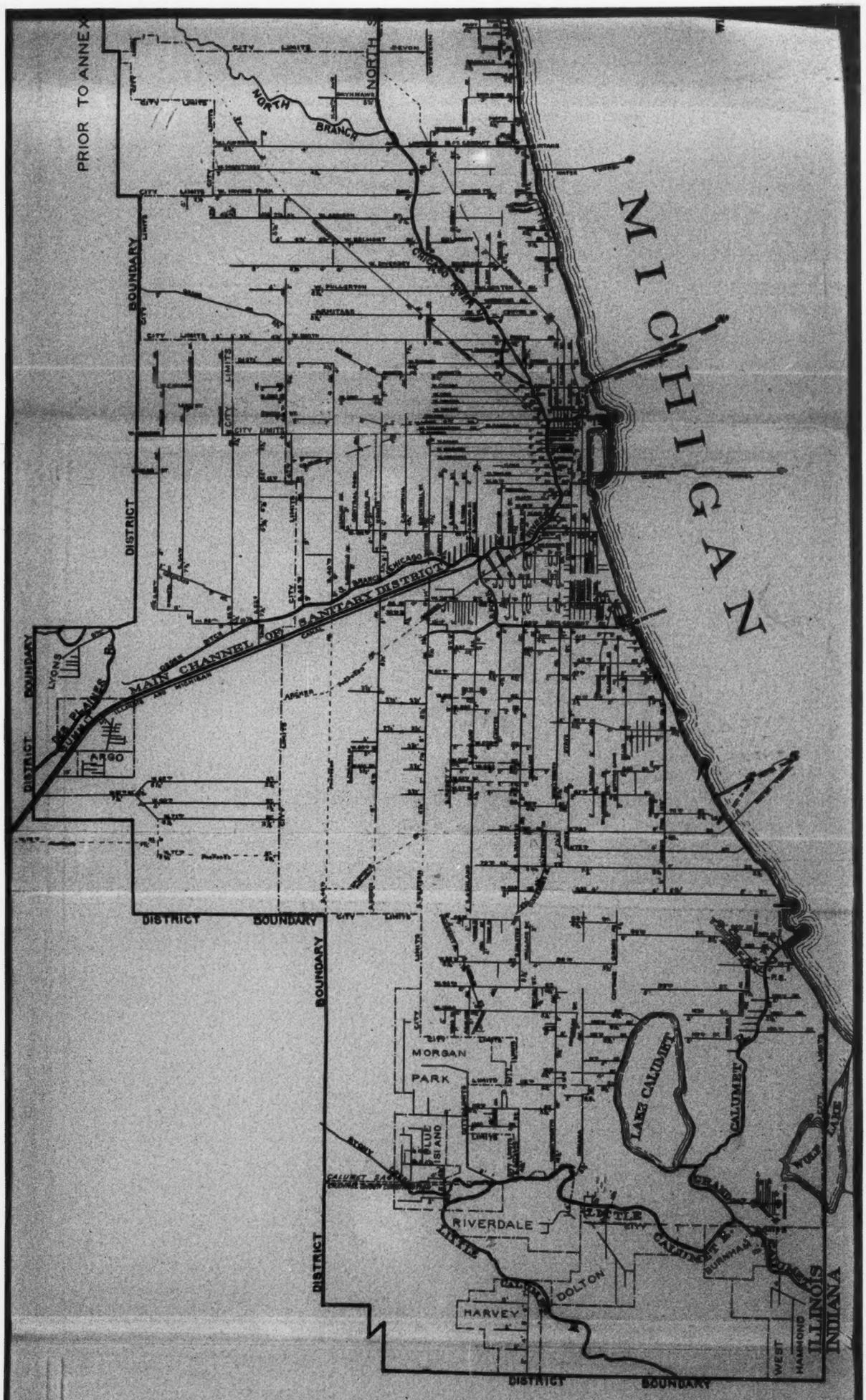
SCHODER EXHIBIT 11.

Dec. 13, 1913.

SCHODER EXHIBIT 12.
Dec. 13, 1913.

CORNELL UNIVERSITY HYDRAULIC LABORATORY CANAL DISCHARGE MEASUREMENTS BY HASKELL CURRENT METER

No. of Meas.	Distance down stream from Baffles, feet	Mean depth of water in feet	Discharge by meter c. f. s.	Discharge by Weir c. f. s.	Deficiency in discharge by meter c. f. s.	% Deficiency of meter meas.
1	51	3.96	159.4	170.6	11.2	6.6
2	260	4.40	161.9	170.6	8.7	5.1
3	51	2.62	164.3	170.6	6.3	3.7
4	88	2.73	161.6	170.6	9.0	5.3
5	208	2.91	165.0	169.6	4.6	2.7
6	41	7.12	166.3	170.5	4.2	2.5
7	67½	7.19	160.3	169.5	9.2	5.4
8	208	7.44	160.4	168.0	7.6	4.5
9	41	7.00	152.3	168.3	16.0	9.5



SANITARY DISTRICT OF CHICAGO

MAP OF THE

CITY OF CHICAGO AND VICINITY

SHOWING

MAIN OUTFALL SEWERS.

CHICAGO JANUARY, 1914.

SCALE IN STATUTE MILES

PRIOR TO ANNEXATION 1913

DISTRICT BOUNDARY

LYONS

DES PLAINES

MAIN CHANNEL OF SANITARY DISTRICT

CITY LIMITS

NORTH BRANCH

MORTON GROVE

NILES CENTER

NORTH SHORE CHANNEL

WINNETKA

GLENCOE

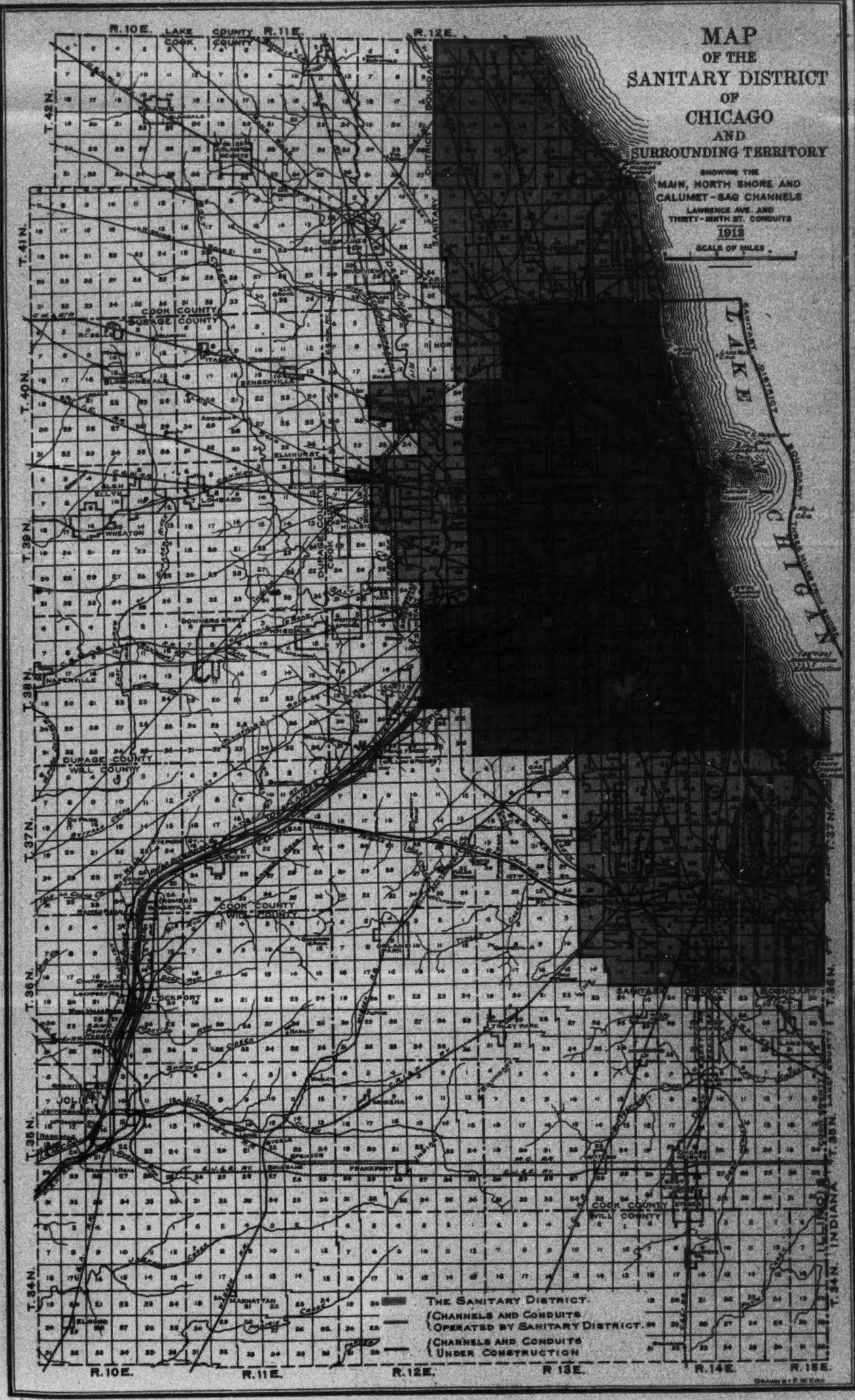
GROSS POINT

LAKE MICHIGAN

Wisner Exhibit 1, January 20, 1914.

Wisner Exhibit 2.

Wisner Exhibit 2.



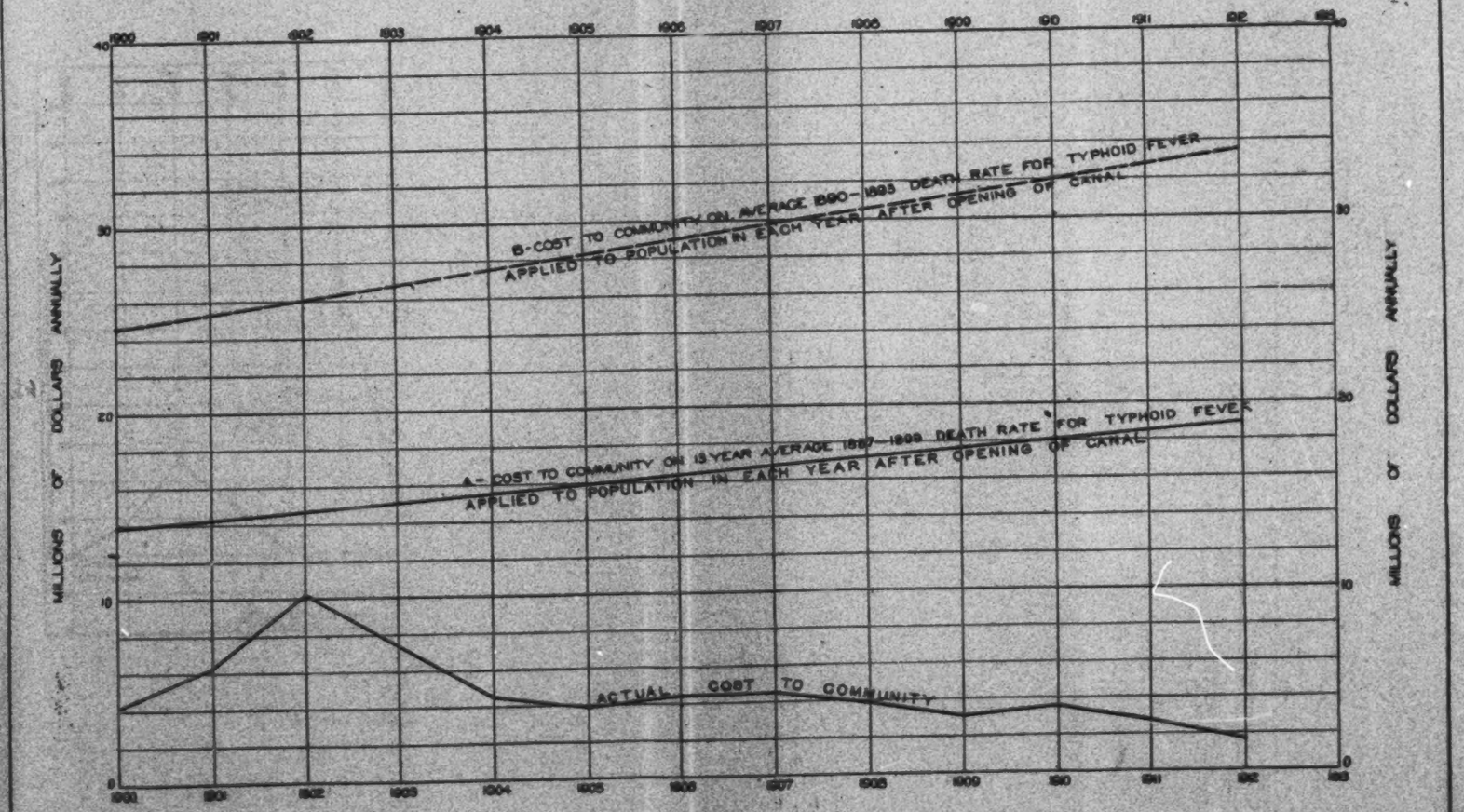
ORIGINAL SANITARY DISTRICT SHOWN IN GREEN.

THE SANITARY DISTRICT OF CHICAGO

CHART SHOWING SAVING TO COMMUNITY BY REDUCTION OF TYPHOID FEVER

SINCE OPENING OF DRAINAGE CANAL

JANUARY 2, 1900.



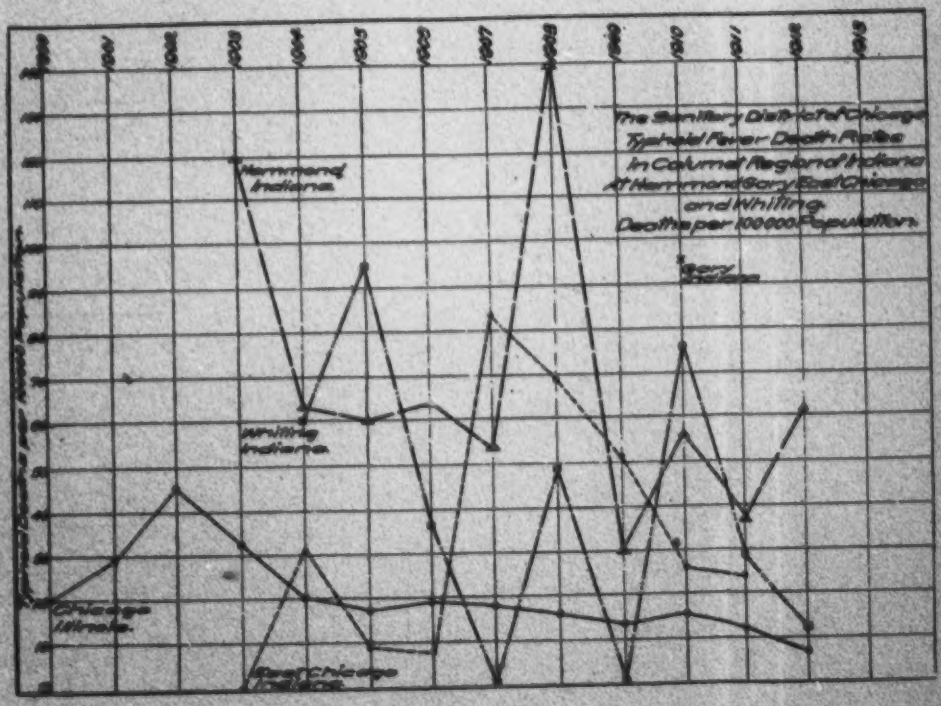

The Sanitary District of Chicago
Typhoid Fever Death Rate
In Calumet Region of Indiana
At Hammond Gary East Chicago
and Whiting.
Deaths per 100000 Population.
Hammond Indiana.
Whiting Indiana.
Chicago Illinois.
East Chicago Indiana.
Gary Indiana.

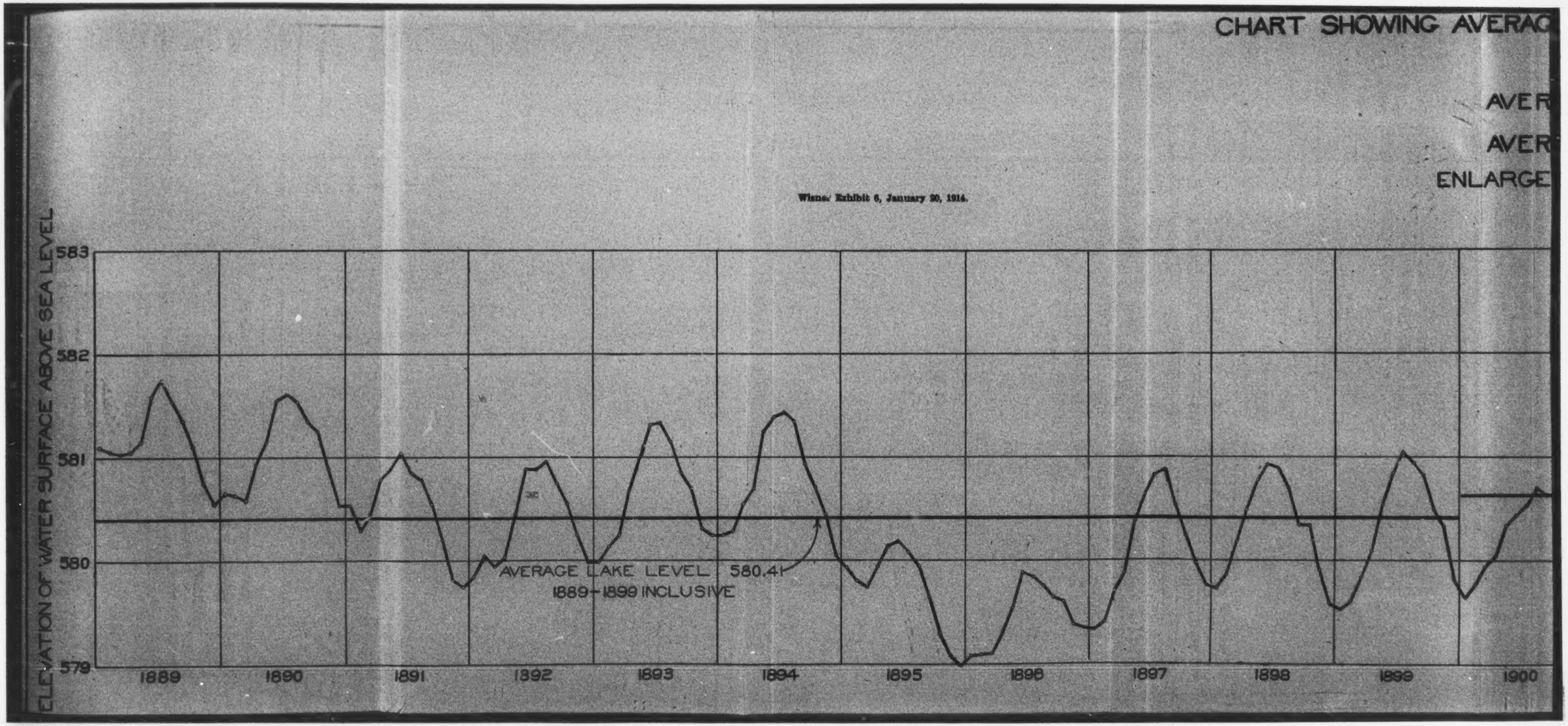
CHART SHOWING AVERAG

AVER

AVER

ENLARGE

Wisner Exhibit 6, January 20, 1914.



VERAGE MONTHLY LEVEL OF LAKE MICHIGAN FROM 1889 TO DATE

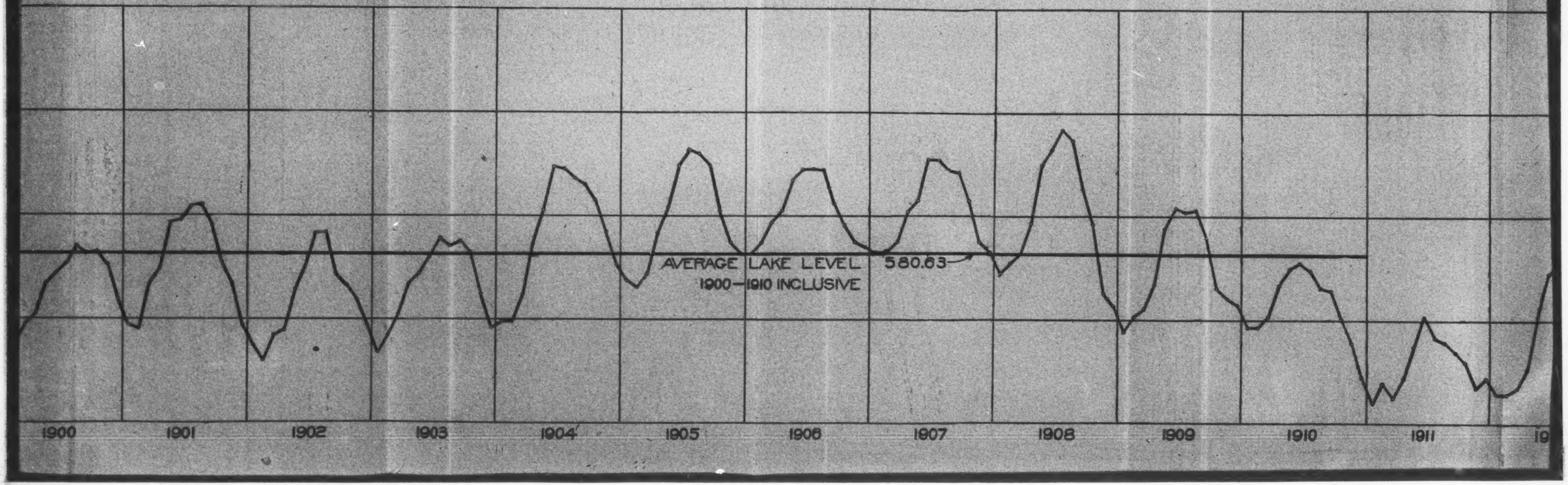
AND

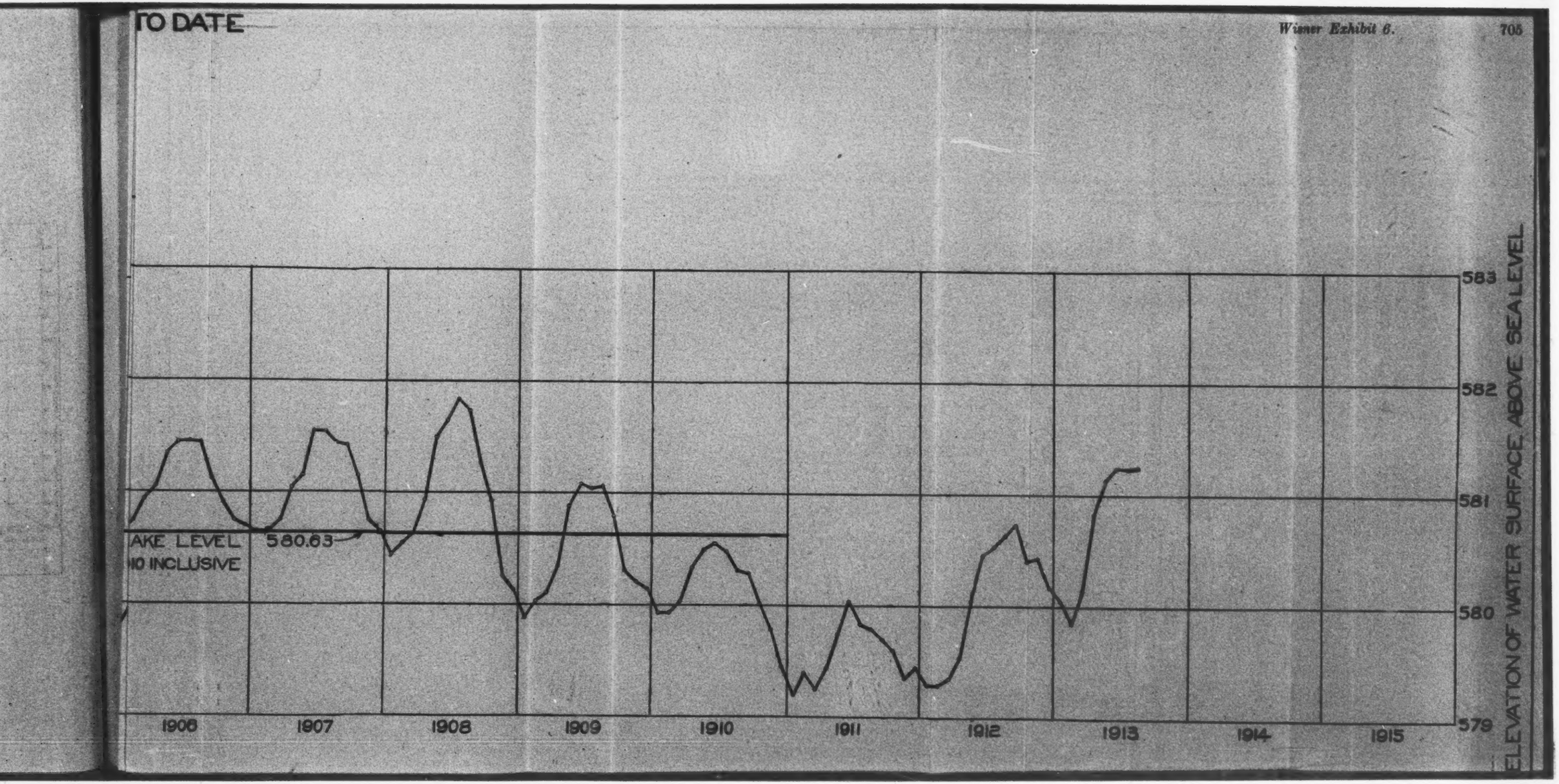
AVERAGE LAKE LEVEL 1889 TO 1899 INCLUSIVE

AVERAGE LAKE LEVEL 1900 TO 1910 INCLUSIVE

ARGED FROM UNITED STATES LAKE SURVEY CHART

AUGUST 1913




TO DATE
AKE LEVEL
10 INCLUSIVE
580.63
583
582
581
580
579
ELEVATION OF WATER SURFACE ABOVE SEA LEVEL
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915

COMPLAINANTS EXHIBITS.

IN

REBUTTAL.

Address: Iroquois, Ontario.

U. S. Lake Survey Detroit, Mich., Sept. 16, 1913.		
Rep.	5	103

UNITED STATES LAKE SURVEY.

Ogdensburg, N. Y., Sept. 15, 1913.

From W. S. Richmond, Junior Engineer.

To District Engineer Officer, U. S. Lake Survey, Old Custom House, Detroit, Mich.

Subject: Preliminary Report, Hydraulics of Niagara River, 1913.

1. In accordance with your instructions, contained in letters dated June 13th and 30th, July 5th, August 12th and 22nd and September 3rd, hydraulic measurements of the Niagara River were made between July 5th and September 4th, inclusive.

2. Measurements of the volume of flow were made at two sections, one on each side of Grand Island, each section being about 4¼ miles below the foot of Squaw Island. Although, from the standpoint of configuration of the channel, slightly better sections might have been obtained further down stream, the adopted sections were selected because of the facilities they offered for range systems, and because of their nearness to a proper base of supplies.

3. The section in the west channel was called Oakfield, that in east channel, Wickwire. The field sheets of the upper Niagara River show the channels to be sufficiently smooth for some distance above and below the sections. There was no boiling or eddying of the water past or near the sections, and the average velocity was less than three feet per second. An inspection of the profiles and transverse and vertical curves, shows that good conditions for gaging obtained.

4. Practically the same equipment was used as on the St. Clair River in 1910, and on the St. Lawrence River in 1911. The personnel of the party was likewise much the same. Almost all the observing was done by the writer, or by Junior Engineer Albert B. Jones, who has been his ranking assistant for the past three years. In general, the same methods were used and standards of accuracy observed as in preceding years and set forth in various reports by the writer and others. Practically nothing in the line of field or office work was left unchecked. It was not expected, however, that the few measurements of current velocity which could be made in the brief time allotted to this work, would give final results quite as accurate as could be obtained from a much longer series of observations.

5. To one familiar with such work the procedure followed in field work and computations will, for the most part, be evident upon inspection of the field notes and the computations and sketches submitted.

6. At each section the horizontal distances depend on a base line measured with a good 100 foot steel tape, the length of base line being checked from the triangulation of 1909 of the International Waterways Commission.

7. The setting of the cut-off ranges was carefully checked.

RICHMOND'S EXHIBIT No. 1.
Feb. 4, 1914.

8. The rod floats were of rough hemlock, 2 inches square and 14 feet long, weighted at the bottom with scraps of lead to make them float vertically, with the tops projecting about 4 inches out of water. A piece of lath, about a foot long, extended 8 inches higher, and carried a flag 5 inches square.

9. The Buffalo gage was carefully and thoroughly inspected on July 9th and 29th, duplicate wye levels being run between P. B. M. Buffalo lighthouse, and the reference gages on the former date. The gage was also inspected August 18th and September 4th.

10. Small-type self-registering gages were established and maintained at Austin Street, Buffalo, and Chippewa, Ontario, in the exact locations of former gages. Unfortunately, the dock at Chippewa burned August 7th, destroying the gage, but the record was later rescued from the water, practically uninjured.

11. At the sections box gages were installed. Distances were measured with a wooden staff from a point on the top of the box down to the water inside.

12. Levels in duplicate were run to the reference points of all gages, from neighboring benchmarks, when the gages were installed, and when they were removed. All staffs were carefully tested.

13. Soundings were made exactly on section with a 140 pound cast iron weight suspended by number 30 steel piano wire. Locations were by cut-off angles read with a transit on shore, and were computed to the nearest foot.

14. Four Haskell current meters were used on their 40 pound weights. During current measurements for discharge or coefficient determination, two meters at a time were suspended 4 feet apart in the central forward part of the catamaran, 4 feet forward of the line joining the points at which the pontoon bows cut the water. The steering wheel, which was 15 feet astern of the port meter, was held on station.

15. Meters were rated two at a time, suspended from a cross-boom, so that each meter was 3½ feet from the side of the rating boat and 6 feet under water. The working draft of the rating boat was one foot.

16. No observations of current velocity were made when a passing vessel was on or near the section. During still-water ratings runs were seldom made when a boat was passing the mouth of the slip at the foot of Hertel Avenue, where the ratings were made, or for several minutes thereafter.

17. The results of rating number 2 are a valuable check on those of rating number 1, but were not used because they differed so very slightly from the first rating. The use of rating 1 for the discharge measurements is logical, and it is perfectly proper for the coefficient observations, where the meters were so used as to tend to eliminate errors of rating.

18. In gaging the flow through the areas at the ends of each section observations were taken while wading, or from the yawl, distances being obtained with tapes and tag-lines, depths with a sounding pole, and velocities with a small Price meter.

19. Water surface elevations at the various gages during discharge measurements were scaled directly from the records, allowing time intervals of −20, −10 and +60 minutes for the Buffalo, Austin St. and Chippewa gages, respectively. These time intervals were estimated from a consideration of carefully determined time intervals on the St. Clair River.

20. A brief summary of the results is as follows:

SECTION WICKWIRE.

No.	Date 1913	Inclusive Time	Water Surface Elev.			Wind	Meters	Disch.
			Buff.	Austin	Chip.			
1	July 30	9:12–11:35	573.35	568.01	563.08	NW 2	1B & 10B	95,200
2	" 30	13:30–16:23	573.01	567.82	563.01	NE 10	10B & 14B	92,800
3	Aug. 1	14:16–16:02	573.19	567.87	563.01	N 15	10B & 14B	93,700
4	" 6	8:56–10:53	573.02	567.82	563.00	0	1B & 10B	93,300
5	" 6	11:06–14:15	573.02	567.76	562.98	NE 3	10B & 15B	91,800
6	" 6	14:29–16:10	573.04	567.77	562.93	0	1B & 15B	92,100
7	" 7	7:47– 9:44	572.85	567.71	562.94	NE 10	1B & 14B	91,900
8	" 7	9:59–11:47	572.84	567.67	562.92	0	1B & 10B	90,800
9	" 7	13:12–15:46	572.88	567.64	562.89	N 10	10B & 15B	90,300
10	" 9	9:17–11:27	572.53	567.09	.....	SW 15	14B & 15B	87,400
Means			573.06					91,900

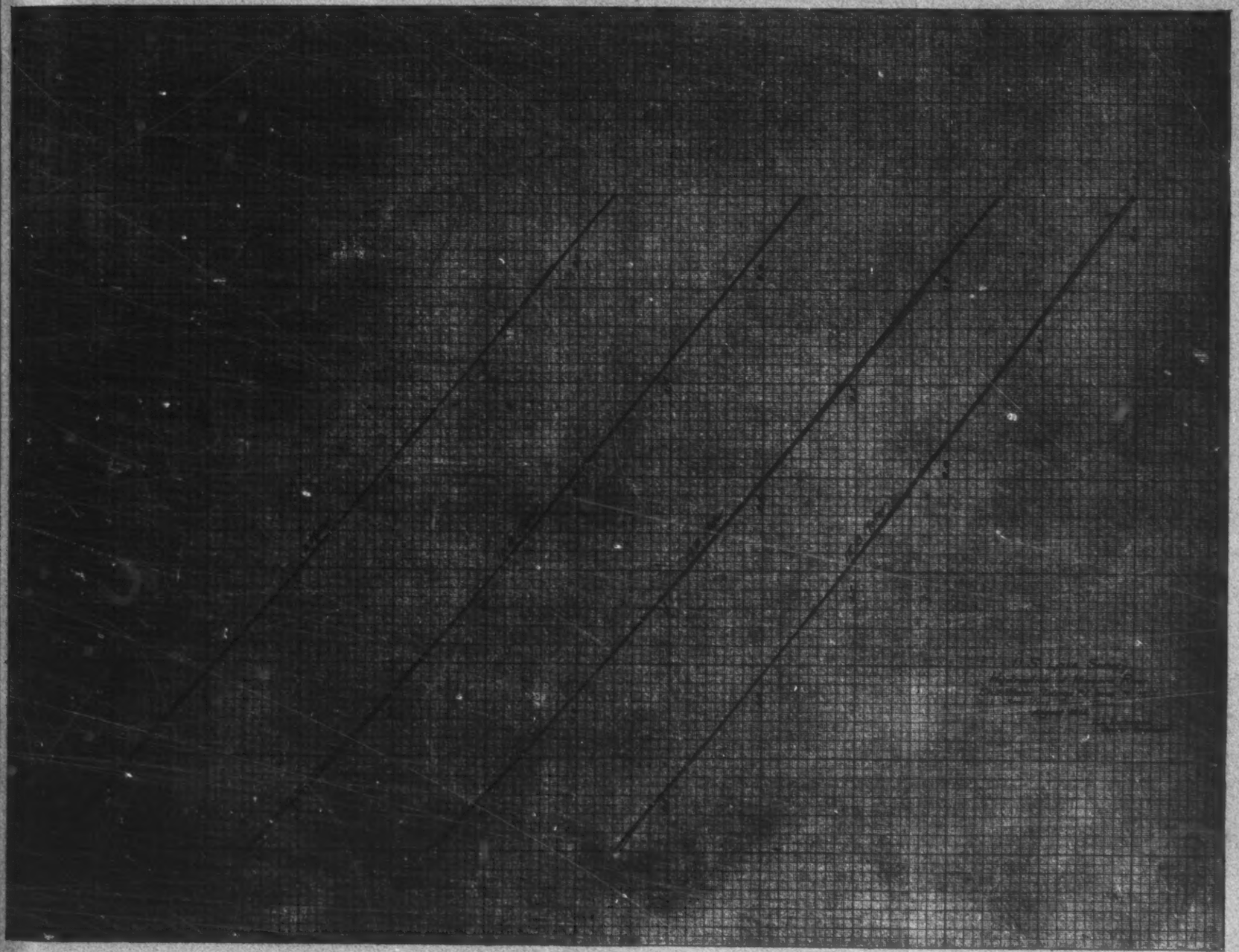
SECTION OAKFIELD.

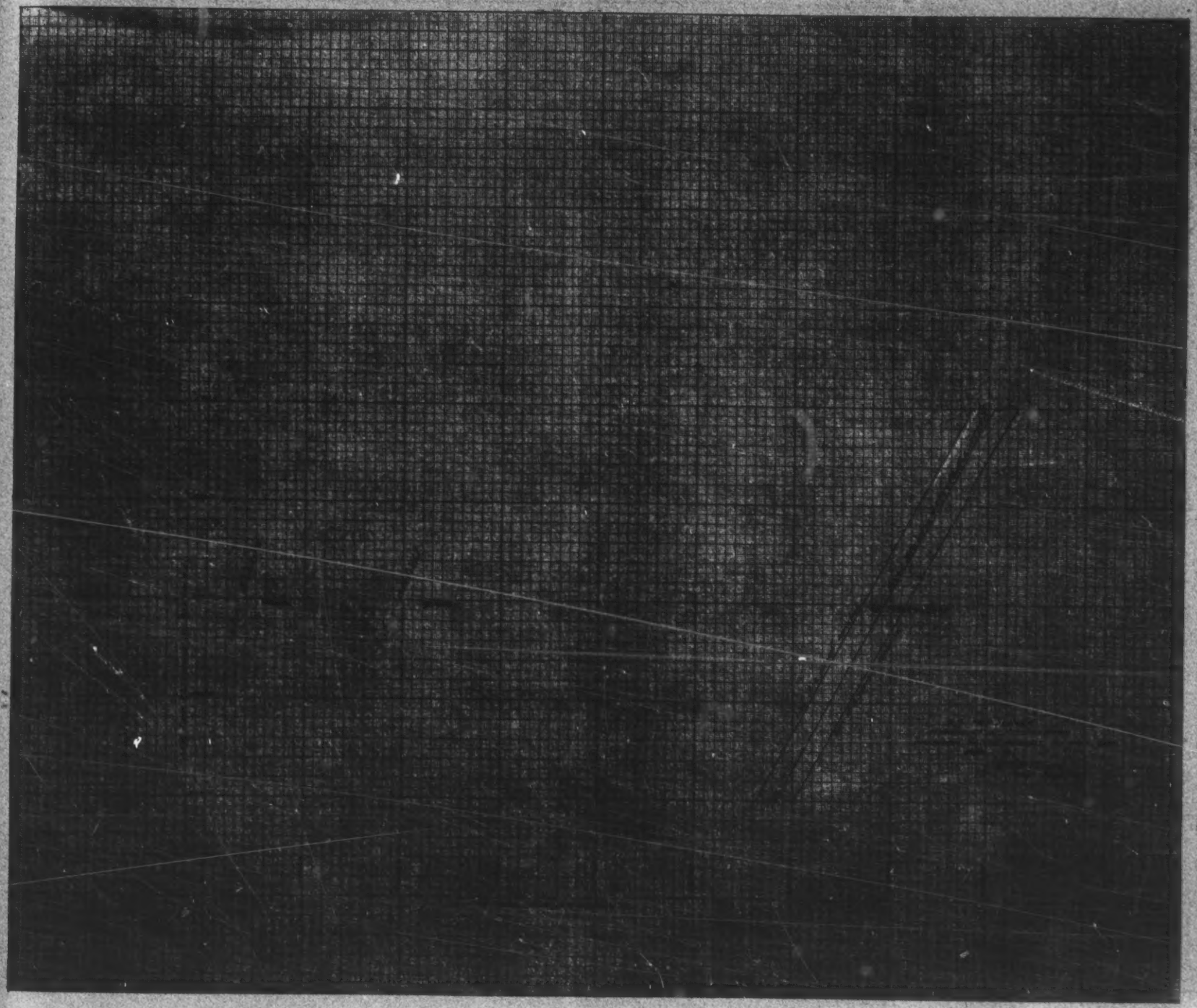
No.	Date 1913	Inclusive Time	Water Surface Elev.			Wind	Meters	Disch.
			Buff.	Austin	Chip.			
1	July 31	8:34–10:53	573.19	567.83	562.98	S 5	14B & 15B	127,900
2	" 31	11:08–14:22	573.23	567.86	563.01	S 2	1B & 15B	126,700
3	" 31	14:41–16:18	573.23	567.92	563.04	0	1B & 10B	129,100
4	Aug. 2	8:37–10:37	573.51	568.06	563.09	NW 11	14B & 15B	130,400
5	" 11	9:00–11:01	572.72	567.23	.....	E 10	1B & 10B	119,600
6	" 11	11:19–14:55	572.77	567.47	.....	E 27	10B & 14B	121,900
7	" 11	15:13–16:56	572.30	567.26	.....	E 10	14B & 15B	118,500
8	" 12	8:00–10:03	573.11	567.78	.....	E 5	10B & 15B	125,500
9	" 12	10:21–13:43	572.96	567.75	.....	0	10B & 14B	124,200
10	" 12	14:00–15:40	572.78	567.62	.....	S 6	14B & 15B	123,100
Means			573.06					124,900

Combining the above means, the final result becomes:

Buffalo Gage.	RIVER DISCHARGE. Observed.	Computed.	RESIDUAL C. F. S.	Per cent.
572.98	216,800	218,000	−1200	−0.6

W. S. RICHMOND.





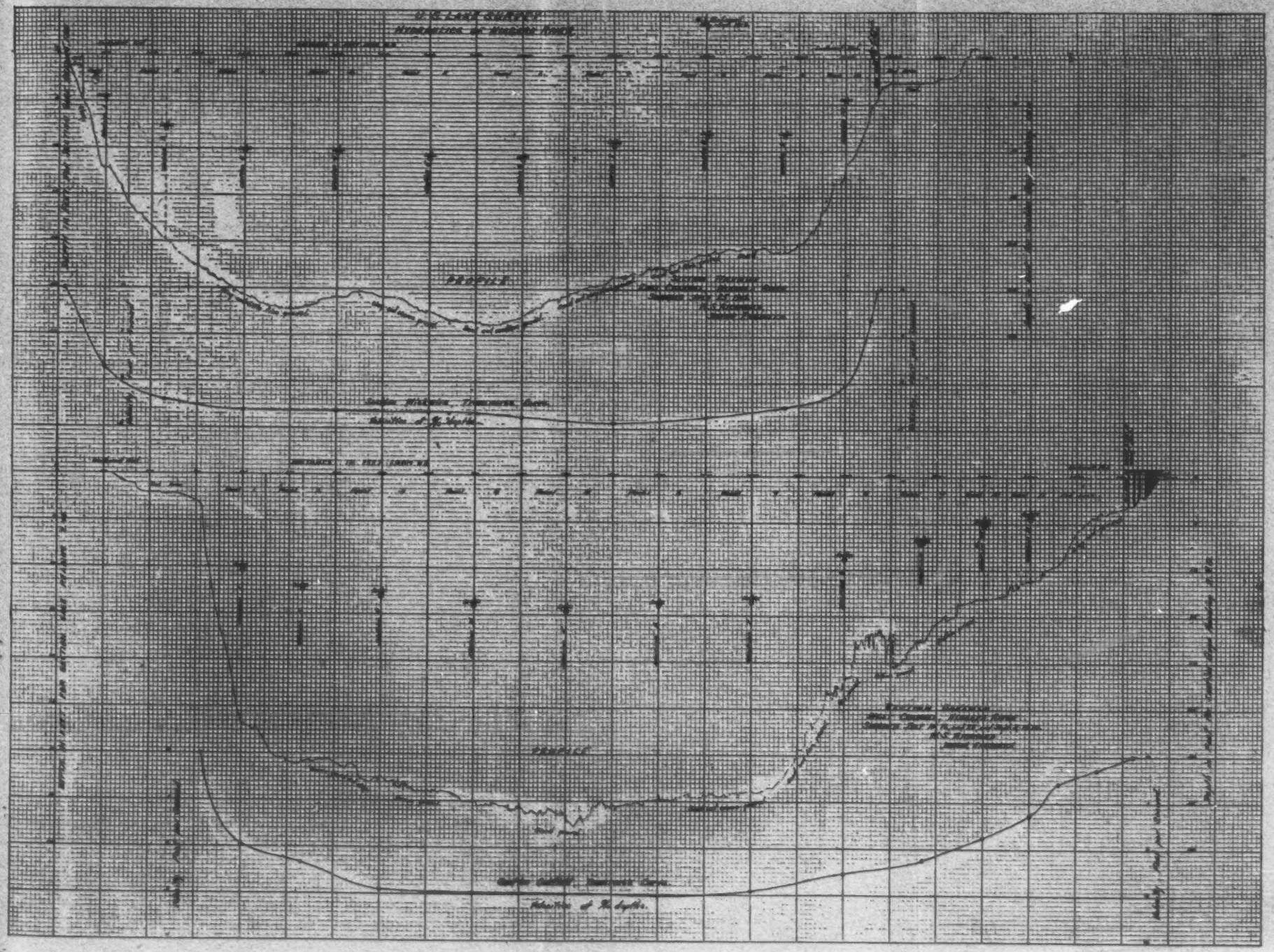


Table 2.
In 4 Sheets.
Sheet 1.

U. S. LAKE SURVEY.

CHICAGO DRAINAGE CANAL.

Measurements of Flow by Index Meter.

LEMONT, ILL.

Elevations depend on
U. S. P. B. M. 99—591.569
U. S. P. B. M. 114—594.121
U. S. P. B. M. 120—592.133

Sherman Moore, Jun. Engr.
Jan. 1914

No.	Date 1913	Time	Meter	Index Velocity Ft. per Sec.	Mean Velocity Ft. per Sec.	Area Sq. Ft.	Flow C. F. S.	Water Surface Elevations			Fall to Lemont from		Wind	
								Lake Mich.	Willow Springs	Lemont	Lake	Willow Springs	Dir.	Vel.
1	Dec. 16	15:22-15:46	15-B	1.64	1.49	4015	5963	580.04		576.99	3.05		SW	8
2		15:47-16:18	15-B	1.71	1.55	4023	6236	580.04		577.04	3.00			
3		16:18-16:46	15-B	1.65	1.49	4024	5998	580.04		577.05	2.99			
4	Dec. 17	10:05-10:30	10-B	1.88	1.66	3585	5957	579.84		576.19	3.65			
5		10:36-10:57	10-B	1.67	1.53	3553	5453	579.84		576.21	3.63		W	20
6		11:37-11:57	10-B	1.62	1.45	3901	5657	579.74		576.29	3.45		W	20
7		13:14-13:34	15-B	1.68	1.52	3964	6025	579.73		576.68	3.10			
8		13:35-14:00	15-B	1.65	1.49	3974	5921	579.84		576.74	3.10			
9		14:00-14:44	15-B	1.70	1.54	3923	6122	579.85		576.79	3.16			
10		15:10-15:39	10-B	1.68	1.52	4013	6100	580.04		576.96	3.04		W	8
11		15:40-16:05	10-B	1.82	1.63	4023	6438	580.04		577.04	3.00			
12		16:07-16:27	10-B	1.68	1.52	4029	6134	580.04		577.05	2.98			
13		16:27-16:47	10-B	1.60	1.45	4032	5846	580.04		577.10	2.94			
14	Dec. 18	9:21- 9:43	10-B	2.06	1.87	2726	6966	580.19		575.20	4.99		N	6
15		9:50-10:13	10-B	1.97	1.78	2751	6677	580.24		575.36	4.88			
16		10:16-10:39	10-B	1.93	1.77	2772	6676	580.25		575.40	4.76			
17		10:47-11:08	10-B	1.89	1.71	2793	6488	580.24		575.62	4.62		NW	2
18		11:09-11:26	10-B	1.83	1.66	2813	6328	580.20	576.21	575.74	4.46	0.47		
19		11:37-12:01	10-B	1.78	1.61	2841	6099	580.15	576.32	575.92	4.23	0.40		
20		12:02-12:22	10-B	1.71	1.55	3967	5994	580.10	576.40	576.08	4.02	0.32		
21		13:31-13:56	15-B	1.65	1.49	3940	5871	580.20	576.80	576.53	3.67	0.27	N	4
22		13:57-14:21	15-B	1.71	1.55	3961	6140	580.36	576.96	576.66	3.80	0.33		
23		14:35-14:57	15-B	1.76	1.59	3976	6322	580.22	577.06	576.73	3.57	0.33		
24		14:58-15:20	15-B	1.70	1.54	3983	6142	580.25	577.17	576.83	3.55	0.34		

MOORE'S EXHIBIT 2, FEB. 5, 1914.

Table 2.
In 4 Sheets.
Sheet 2.

U. S. LAKE SURVEY.
CHICAGO DRAINAGE CANAL.
Measurements of Flow by Index Meter
LEMONT, ILL.

Elevations depend on
U. S. P. B. M. 99—591.569
U. S. P. B. M. 114—594.121
U. S. P. B. M. 130—592.133

Sherman Moore, Jun. Engr.
Jan. 1914

No.	Date 1913	Time	Meter	Index Velocity Ft. per Sec.	Mean Velocity Ft. per Sec.	Area Sq. Ft.	Flow C. F. S.	Water Surface Elevations			Fall to Lemont from		Wind	
								Lake Mich.	Willow Springs	Lemont	Lake	Willow Springs	Dir.	Vel.
25	Dec. 18	15:23-15:45	15-B	1.67	1.51	4010	6055	580.40	577.24	576.96	3.44	0.28	N	4
26		15:46-16:06	15-B	1.64	1.49	4023	5994	580.44	577.33	577.04	3.40	0.29		
27		16:08-16:24	15-B	1.62	1.47	4022	5923	580.44	577.38	577.08	3.36	0.30		
28		16:34-16:45	15-B	1.62	1.47	4036	5933	580.44	577.46	577.12	3.32	0.34		
29	Dec. 19	9:58-10:23	10-B	1.70	1.53	3917	6346	579.96	576.79	576.39	3.80	0.40	SW	12
30		10:33-10:49	10-B	1.71	1.55	3960	6143	580.03	576.96	576.62	3.80	0.34		
31		10:50-11:27	10-B	1.70	1.61	3943	6346	580.04	576.98	576.63	3.81	0.43		
32		11:28-11:56	10-B	1.78	1.61	3940	6343	579.88	576.97	576.55	3.33	0.42		
33		13:06-13:36	15-B			4011	5896	579.78	577.27	576.97	2.81	0.30		
34		[illegible]	15-B				5901	579.74	577.28	577.00	2.74	0.28		
35		[illegible]	15-B			4032	5894	579.78	577.37	577.10	2.68	0.27		
36		[illegible]	15-B			4057	5871	579.90	577.42	577.13	2.77	0.29		
37		[illegible]	15-B	1.52	1.39	4047	5622	579.94	577.46	577.19	2.75	0.27	SW	8
38		15:01-15:20	15-B	1.48	1.34	4063	5443	579.94	577.53	577.28	2.66	0.25		
39		15:21-15:56	15-B	1.45	1.34	4073	5530	579.94	577.60	577.35	2.59	0.25		
40		15:56-16:21	15-B	1.50	1.36	4079	5803	579.94	577.64	577.37	2.57	0.27	SW	4
41		16:22-16:33	15-B	1.49	1.35	4039	5525	580.16	576.37	575.90	4.26	0.47		
42	Dec. 20	9:10- 9:33	10-B	1.88	1.70	3884	6706	580.22	576.44	576.00	4.23	0.44		
43		9:34-10:01	10-B	1.92	1.74	3875	6836	580.31	576.57	576.13	4.18	0.44		
44		10:14-10:29	10-B	1.89	1.71	3876	6412	580.40	576.64	576.20	4.20	0.44		
45		10:30-11:05	10-B	1.82	1.65	3898	7124	580.44	576.73	576.18	4.26	0.55		
46		11:14-11:47	15-B	2.04	1.85	3853	7129	580.44	576.74	576.20	4.24	0.54		
47		11:50-12:24	15-B	2.04	1.85	3898	7189	580.44	577.25	577.18	3.26	0.07		
48		12:44-14:16	10-B	1.37	1.24	4045	5016	580.39	577.45	577.31	3.08	0.14		
49		14:17-14:46	10-B	1.26	1.23	3986	5001							

Moore's Exhibit 2.

Table 2. In 4 Sheets. Sheet 3.

U. S. LAKE SURVEY.

CHICAGO DRAINAGE CANAL.

Measurements of Flow by Index Meter.

LEMONT, ILL.

Elevations depend on
U. S. P. B. M. 99—591.589
U. S. " 114—594.131
U. S. " 4. 120—592.133

Sherman Moore, Jun. Engr.
Jan. 1914

No.	Date 1913	Time	Meter	Index Velocity Ft. per Sec.	Mean Velocity Ft. per Sec.	Area Sq. Ft.	Flow C. F. S.	Water Surface Elevations			Fall to Lemont from		Wind	
								Lake Mich.	Willow Springs	Lemont	Lake	Willow Springs	Dir.	Vel.
49	Dec. 20	14:40-15:07	10-B	1.32	1.30	4097	4916	580.34	577.62	577.50	2.84	0.12	N	6
50		15:07-15:34	10-B	1.30	1.18	4122	4864	580.34	577.77	577.65	2.69	0.12	N	6
51		15:35-15:59	10-B	1.49	1.35	4123	5566	580.34	577.91	577.66	2.43	0.25		
52		16:01-16:25	10-B	1.46	1.33	4131	5483	580.34	577.93	577.71	2.63	0.22	N	10
53		16:25-16:51	10-B	1.44	1.30	4156	5402		577.98	577.86		0.12		
54		16:55-17:00	10-B	1.38	1.70	4117	6999		578.06	577.62		0.44		
55		17:33-18:06	15-B	1.97	1.78	4071	7246		577.98	577.34		0.64	N	8
56		18:06-18:37	15-B	2.06	1.87	4065	7602		577.80	577.30		0.50		
57		18:37-19:13	15-B	2.03	1.84	4045	7443		577.75	577.18		0.57		
58		19:13-19:44	15-B	1.99	1.80	4031	7256		577.59	577.09		0.50		
59		19:44-20:15	15-B	2.03	1.84	4021	7399		577.56	577.03		0.53		
60		20:15-21:08	15-B	2.04	1.85	4005	7409		577.45	576.93		0.53		
61		21:28-21:58	10-B	2.15	1.96	3973	7745		577.30	576.73		0.57		
62		21:58-22:21	10-B	2.14	1.94	3961	7684		577.26	576.66		0.60		
63		22:21-22:04	10-B	2.11	1.91	3951	7546		577.20	576.60		0.60		
64		22:04-23:33	10-B	2.10	1.90	3941	7488		577.11	576.54		0.57		
65		23:33-24:04	10-B	2.08	1.88	3923	7394		577.05	576.49		0.56		
66	Dec. 21	0:04- 0:35	10-B	2.09	1.87	3923	7344		577.01	576.46		0.55		
67		0:35- 1:05	10-B	2.08	1.87	3919	7329		576.95	576.40		0.55		
68		3:04- 3:35	15-B	2.13	1.97	3390	7663		576.80	576.22		0.58	N	16
69		3:35- 4:06	15-B	2.14	1.94	3385	7537		576.79	576.19		0.60		
70		4:06- 4:37	15-B	2.17	1.97	3385	7653		576.77	576.19		0.58		
71		4:37- 5:08	15-B	2.12	1.92	3878	7442		576.74	576.14		0.60		
72		5:08- 5:39	15-B	2.14	1.94	3878	7518		576.73	576.13		0.60		

Moore's Exhibit 3.

MOORE'S EXHIBIT 4, FEB. 5, 1914.

Table 2. In 4 Sheets. Sheet 4.

U. S. LAKE SURVEY.
CHICAGO DRAINAGE CANAL.
Measurements of Flow by Index Meter.
LEMONT, ILL.

Elevations depend on
U. S. P. B. M. 99—591.560
U. S. P. B. M. 114—594.121
U. S. P. B. M. 120—592.133

Sherman Moore, Jun. Engr.
Jan. 1914.

No.	Date 1913	Time	Meter	Index Velocity Ft. per Sec.	Mean Velocity Ft. per Sec.	Area Sq. Ft.	Flow C. F. S.	Water Surface Elevations			Fall to Lemont from		Wind	
								Lake Mich.	Willow Springs	Lemont	Lake	Willow Springs	Dir.	Vel.
									576.72	576.11		0.61		0
73	Dec. 21	5:30– 6:10	15-B	2.13	1.93	3873	7473		576.69	576.09		0.60		
74		6:10– 6:42	15-B	2.12	1.93	3868	7463		576.68	576.08		0.60		
75		6:42– 7:03	15-B	2.12	1.92	3867	7425		576.70	576.46		0.24		
76		7:03– 7:14	15-B	1.70	1.54	3928	6049		576.70	576.78		0.08		
77		7:14– 7:24	15-B	1.48	1.34	3980	5333		576.92	577.05		0.11		0
78		7:24– 7:46	15-B	1.18	1.07	4024	4306	580.43	577.09	576.66	3.77	0.43		
79	Dec. 22	9:46–10:12	15-B	1.86	1.68	2961	6654	580.45	577.12	576.61	3.84	0.51		
80		10:13–10:29	15-B	1.95	1.77	3953	6997	580.44	577.12	576.80	3.84	0.32		
81		10:29–11:05	15-B	1.95	1.77	3951	6993	580.42	577.13	576.61	3.81	0.52		
82		11:07–11:31	15-B	1.98	1.79	3953	7076	580.38	577.12	576.61	3.77	0.51		
83		11:31–11:56	15-B	1.98	1.79	3953	7076	580.20	577.45	577.18	3.02	0.27	S	4
84		13:03–13:24	15-B	1.56	1.41	4045	5703	580.17	577.48	577.15	3.02	0.33		
85		13:25–13:43	15-B	1.58	1.43	4040	5777	580.14	577.53	577.21	2.93	0.32		
86		13:47–14:08	15-B	1.62	1.47	4050	5954	580.14	577.59	577.27	2.87	0.32		
87		14:09–14:40	15-B	1.66	1.50	4060	6090	580.14	577.62	577.30	2.84	0.32	S	4
88		14:44–15:03	15-B	1.64	1.49	4065	6057	580.14	577.66	577.35	2.79	0.31		
89		15:04–15:37	15-B	1.57	1.42	4073	5784	580.14	577.75	577.46	2.68	0.29		
90		15:50–16:16	10-B	1.60	1.45	4091	5932	580.14	577.80	577.53	2.61	0.27		
91		16:17–16:47	10-B	1.55	1.40	4102	5743	580.14	577.86	577.53	2.61	0.33	NNE	8
92		16:49–17:03	10-B	1.53	1.39	4102	5702		577.87	577.53		0.35		
93		17:03–17:16	10-B	1.73	1.57	4100	6537		577.74	576.96		0.78		
94		17:17–17:49	10-B	2.29	2.07	4010	8301		577.45	576.71		0.74		
		12:40–18:21	10-B	2.26	2.16	3969	8573		577.94	576.66		0.68		

MOORE'S EXHIBIT 5 FEB. 5, 1914

U S LAKE SURVEY

Plate 4.

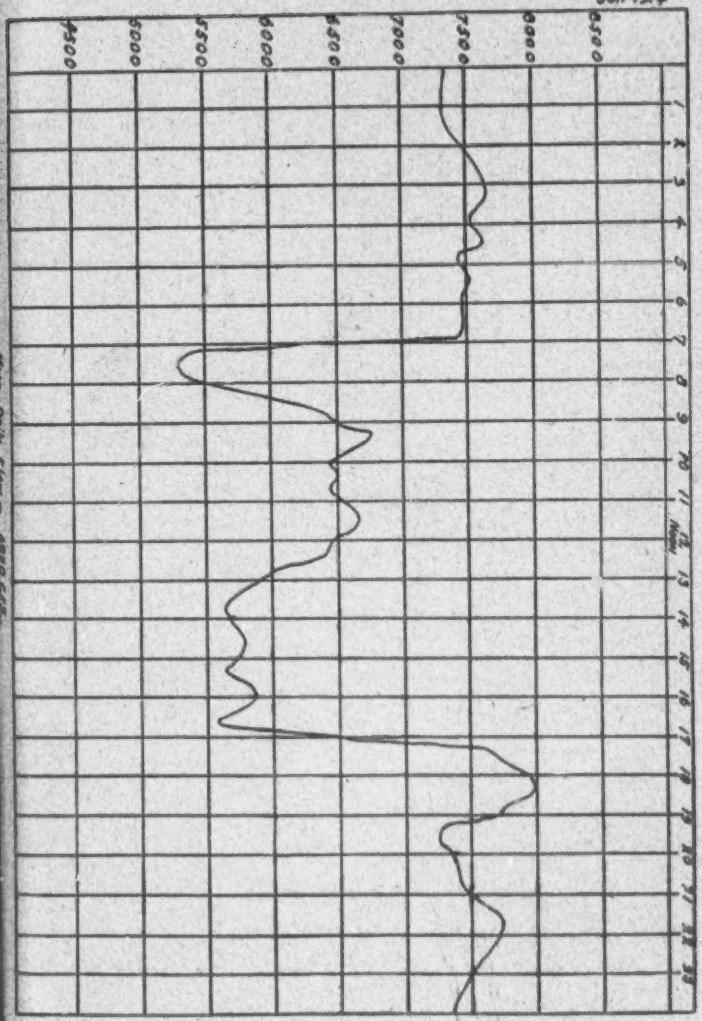
CHICAGO DRAINAGE CANAL

Mean 24 Hour Curve of Flow

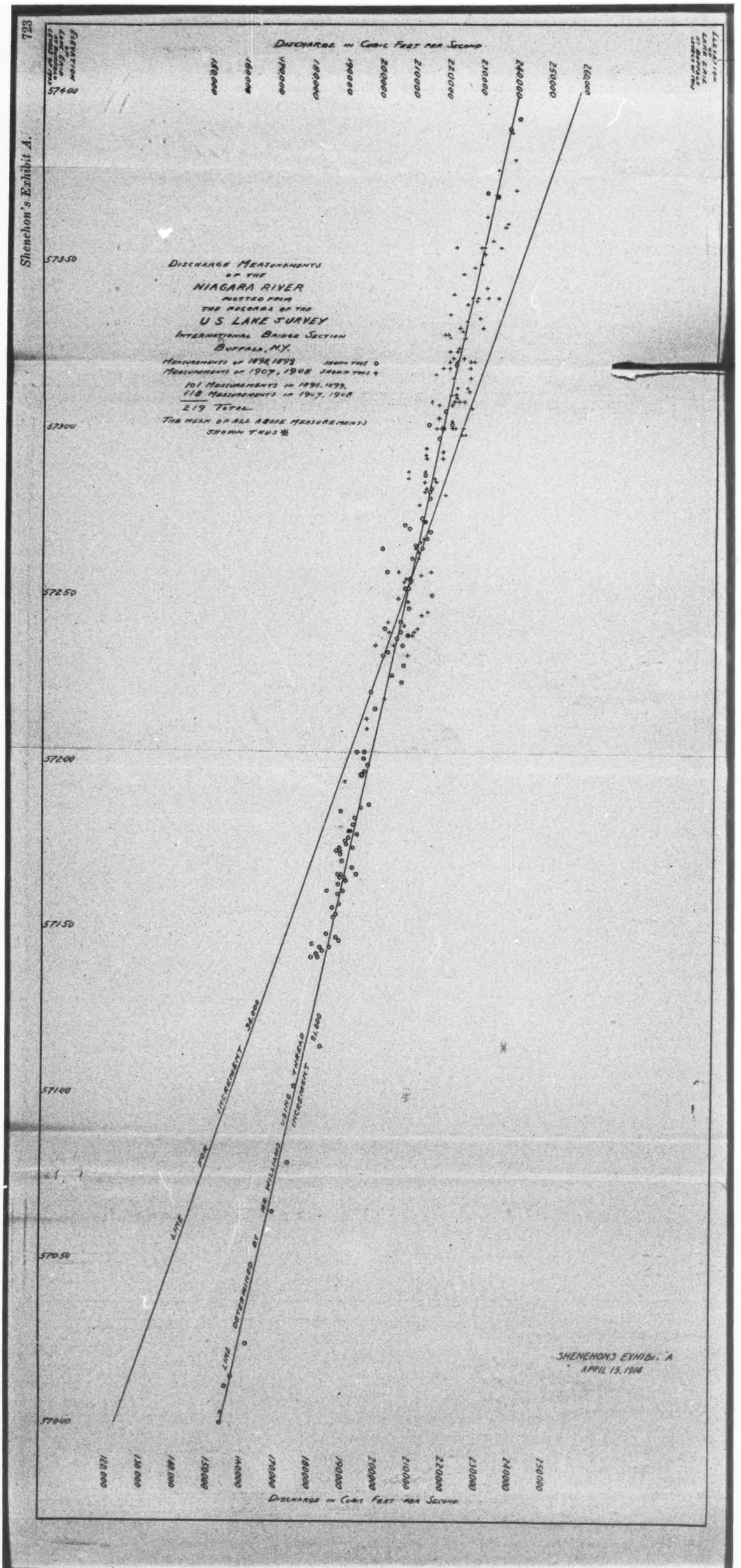
Lemont, Ill

SHERMAN MOORE, Jun. Engr

Jan 1914.

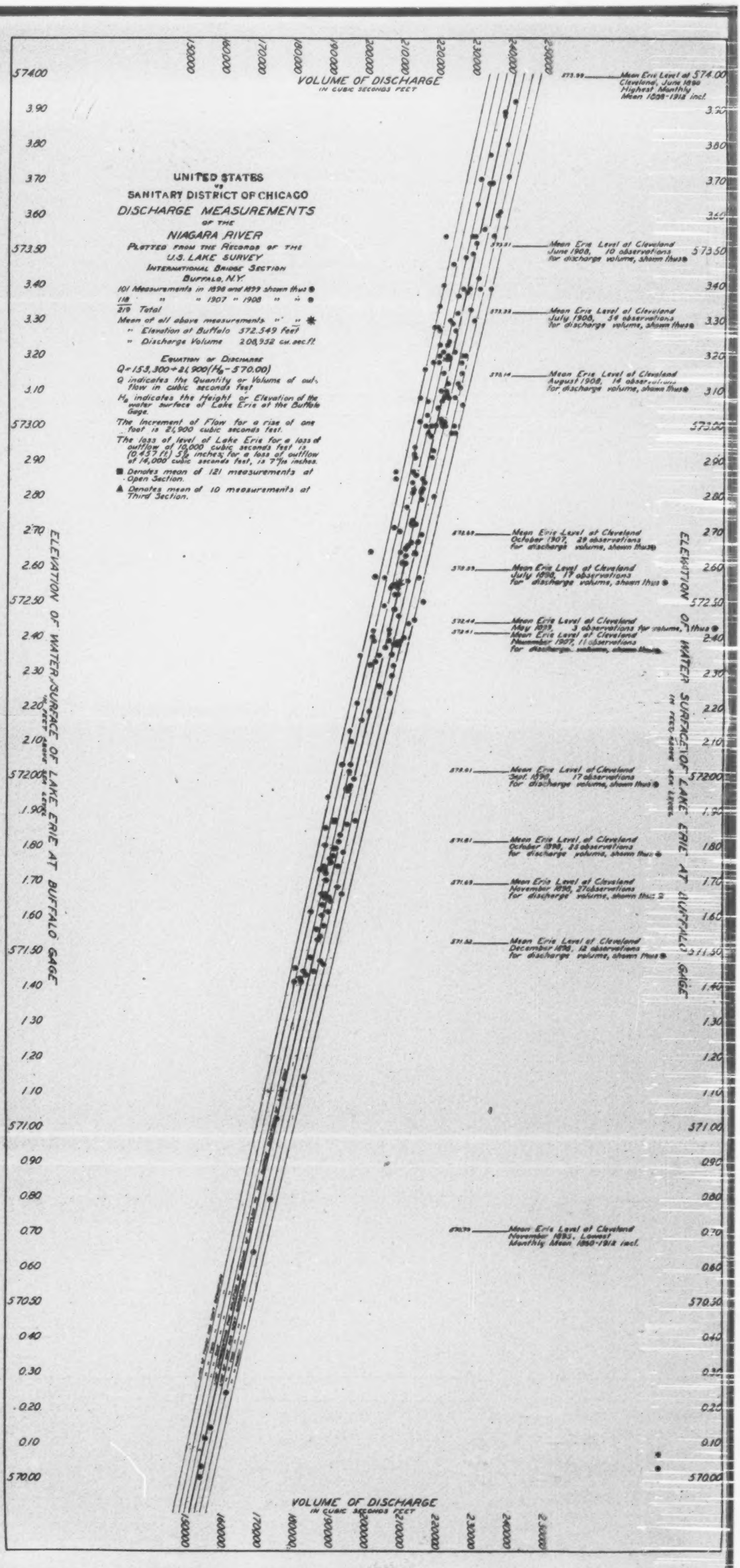


Shenehon's Exhibit A.



Shenehon's Exhibit B.

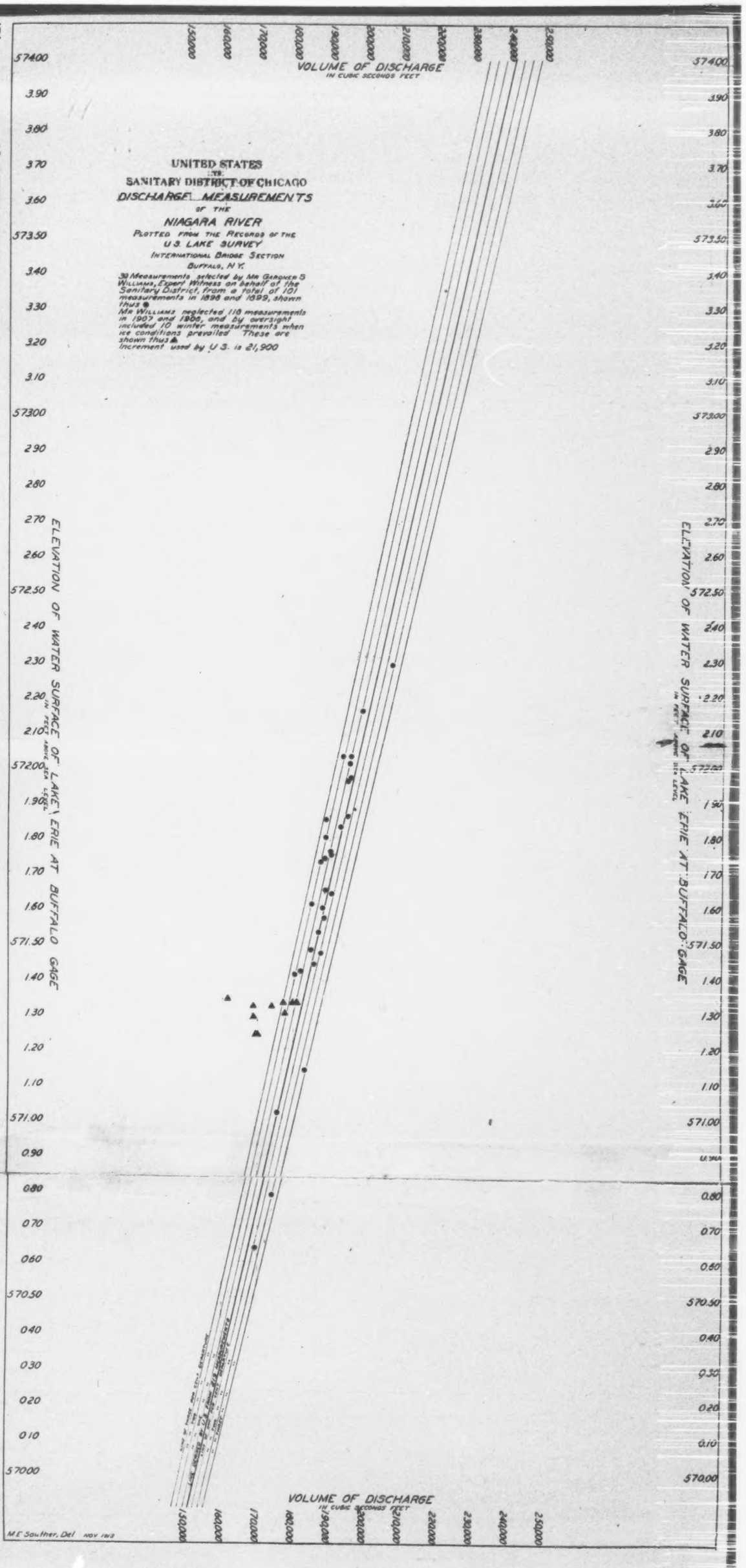
Shenehon's Exhibit B, April 15, 1914.



727

Shenehon's Exhibit C.

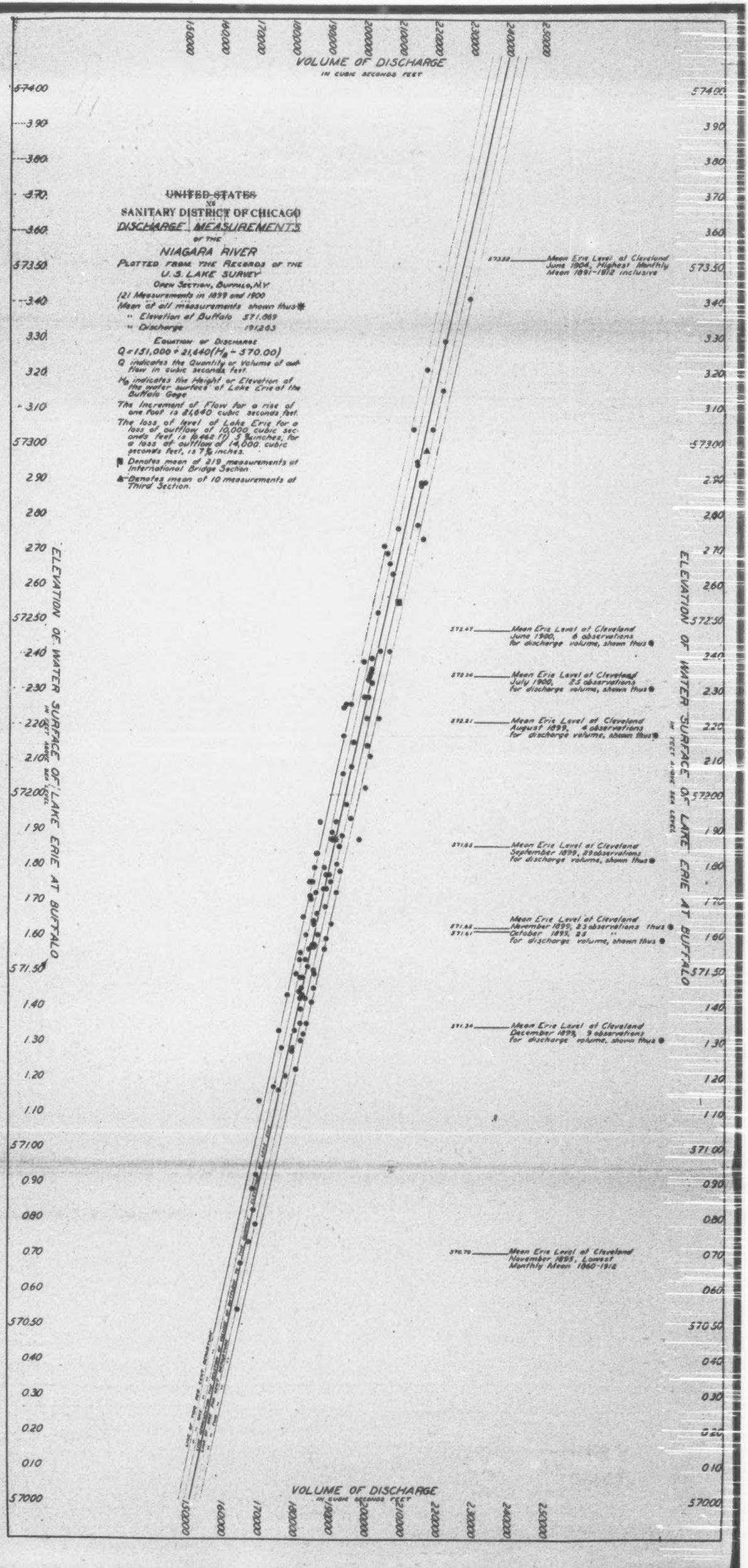
Shenehon's Exhibit C, April 16, 1914.



729

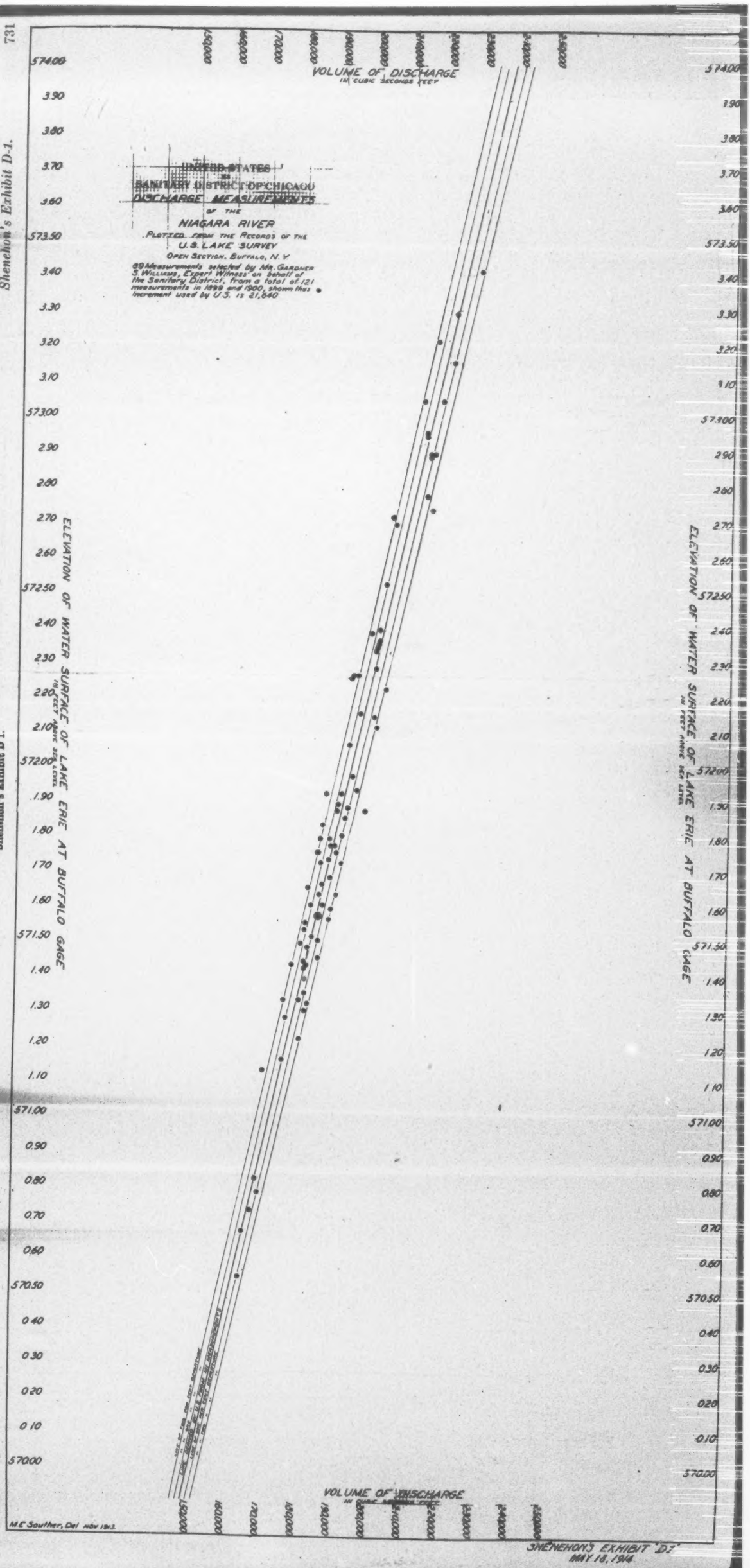
Shenehon's Exhibit D.

Shenehon's Exhibit D' April 15, 1914.



731

Shenehon's Exhibit D-1.

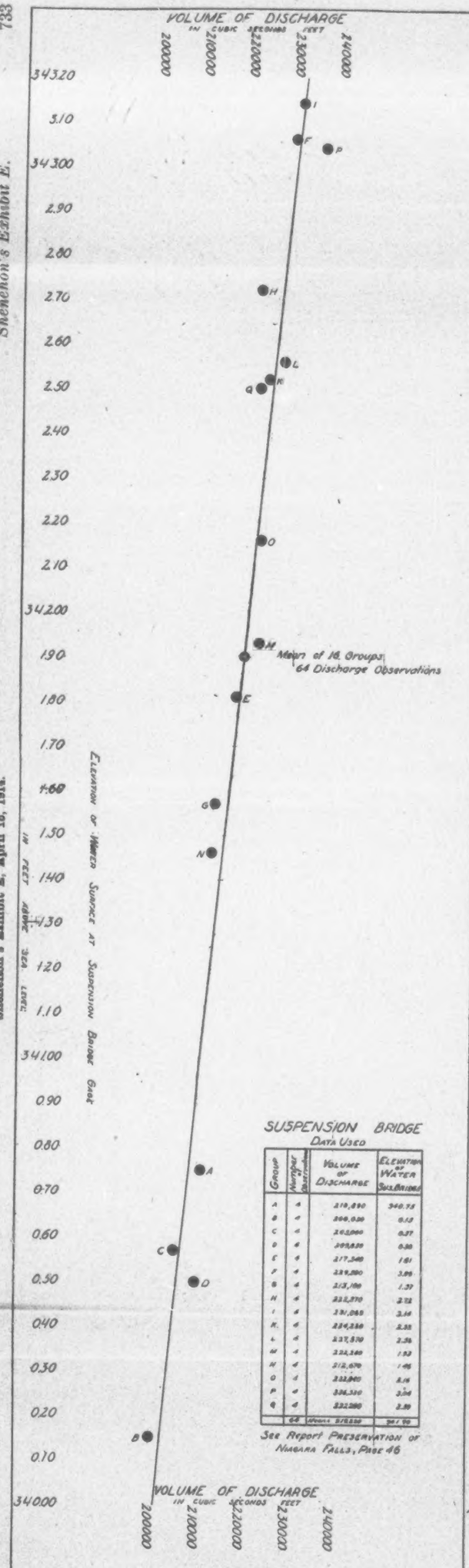


Shenehon's Exhibit D 1.

SHENEHON'S EXHIBIT "D-1"
MAY 18, 1914.

Shenehon's Exhibit E.

Shenehon's Exhibit E, April 16, 1914.



SUSPENSION BRIDGE
Data Used

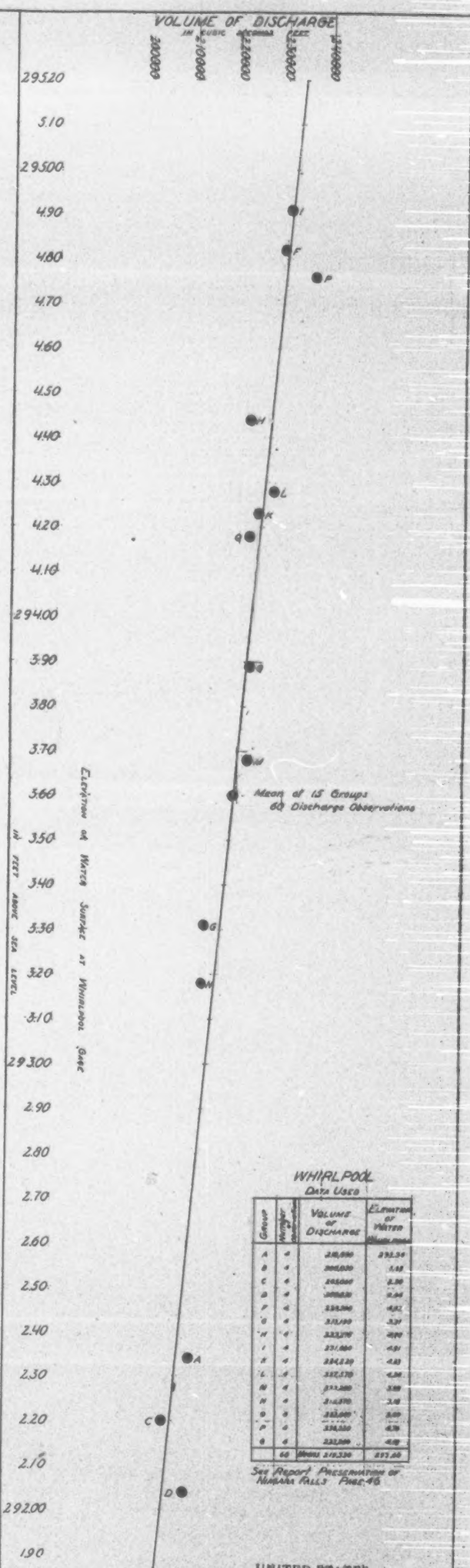
Group	Number Observations	Volume of Discharge	Elevation of Water Surface
A	4	218,690	340.75
B	4	209,030	0.13
C	4	203,000	0.27
D	4	209,830	0.38
E	4	217,340	1.61
F	4	229,290	3.06
G	4	213,190	1.37
H	4	232,270	2.72
I	4	231,060	3.14
K	4	234,230	2.55
L	4	237,570	2.76
M	4	232,340	1.92
N	4	212,070	1.16
O	4	232,840	2.16
P	4	236,330	3.24
Q	4	232,280	2.39
	64	Means 219,330	341.99

See Report Preservation of Niagara Falls, Page 46

UNITED STATES
vs.
SANITARY DISTRICT OF CHICAGO

THE VOLUME OF DISCHARGE OF THE NIAGARA RIVER
PLOTTED WITH RESPECT TO THE ELEVATION OF THE WATER SURFACE AT THE
SUSPENSION BRIDGE GAGE

Equation of Discharge: $Q = 201060 + 9547(H_s - 340.00)$
Increment at Suspension Bridge is 9547
Derived Increment for Lake Erie is $9547 \times 229 = 21860$



WHIRLPOOL
Data Used

Group	Number Observations	Volume of Discharge	Elevation of Water Surface
A	4	218,690	293.34
B	4	209,030	1.88
C	4	203,000	2.36
D	4	209,830	2.84
F	4	229,290	4.61
G	4	213,190	3.31
H	4	232,270	4.19
I	4	231,060	4.91
K	4	234,230	4.33
L	4	237,570	4.56
M	4	232,340	3.99
N	4	212,070	3.18
O	4	232,840	3.69
P	4	236,330	4.79
Q	4	232,280	4.19
	60	Means 219,330	293.80

See Report Preservation of Niagara Falls Page 46

UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO

THE VOLUME OF DISCHARGE OF THE NIAGARA RIVER
PLOTTED WITH RESPECT TO THE ELEVATION OF THE WATER SURFACE AT THE
WHIRLPOOL GAGE

Equation of Discharge $Q = 186,670 + 9083(H_w - 290.00)$
Increment at Whirlpool is 9083
Derived Increment for Lake Erie is $9083 \times 2.47 = 22440$

735

Shenehon's Exhibit F.

Shenehon's Exhibit F, April 15, 1914.

VOLUME OF DISCHARGE.
IN CUBIC SECONDS FEET

200000 210000 220000 230000 240000

ELEVATION OF WATER SURFACE OF NIAGARA RIVER AT SUSPENSION BRIDGE GAGE
IN FEET ABOVE SEA LEVEL

343.50 3.40 3.30 3.20 3.10 343.00 2.90 2.80 2.70 2.60 2.50 2.40 2.30 2.20 2.10 342.00 1.90 1.80 1.70 1.60 1.50 1.40 1.30 1.20 1.10 341.00 0.90 0.80 0.70 0.60 0.50 0.40 0.30 0.20 0.10 340.00

SUSPENSION BRIDGE

DATA USED

Group	Number Observations	Elevation of Water Suspension Bridge Gage	Volume of Discharge
1	10	343.36	234,240
2	10	2.96	228,660
3	10	2.78	225,466
4	10	2.60	223,590
5	10	2.58	224,310
6	10	2.11	221,060
7	10	1.98	219,660
8	10	1.74	218,140
9	10	1.27	213,810
10	10	0.77	210,830
11	10	0.48	207,730
12	8	0.32	201,320
	118	Mean 1.83	219,060

See Report, "PRESERVATION OF NIAGARA FALLS," Page 46, also Page 31.

Note: Group No. 1 contains the ten observations showing the highest elevation of the Suspension Bridge Gage.
Group No. 2 is made up of the ten next lower observations.
Group No 12 contains the eight observations with lowest gage reading.
Others are intermediate in order of gage height.

Mean of 12 groups
118 discharge observations

UNITED STATES
SANITARY DISTRICT OF CHICAGO
THE VOLUME OF DISCHARGE
OF THE NIAGARA RIVER
PLOTTED WITH RESPECT TO
THE ELEVATION OF THE
WATER SURFACE
AT THE
SUSPENSION BRIDGE
GAGE

Equation of Discharge $Q = 201,560 + 3445(H_s - 340.00)$
Increment at Suspension Bridge is 3445
Derived Increment for Lake Erie is $3445 \times 2.33 = 22,000$
The multiplier 2.33 is the ratio of fluctuation of the Suspension Bridge compared with Lake Erie at Cleveland, Ohio. See Exhibit H, Shenehon, April 15, 1914.
Lowerings of Lake Erie indicated by Derived Increment are as follows:
For Diversion of Chicago of 10,000 cu sec ft 5 3/16 inches
4,000 " " " 2 1/16 "
14,000 " " " 7 1/16 "
These conclusions are entirely independent of the Buffalo Gage readings during the observations for Volume of Discharge.

M. E. Shaffner, Del. Dec. 1913.

200000 210000 220000 230000 240000
VOLUME OF DISCHARGE
IN CUBIC SECONDS FEET

Shenehon's Exhibit G.

Shenehon's Exhibit G, April 15, 1914.

VOLUME OF DISCHARGE
IN CUBIC SECONDS FEET

200,000 210,000 220,000 230,000 240,000

ELEVATION OF WATER SURFACE OF NIAGARA RIVER AT WHIRLPOOL GAGE
IN FEET ABOVE SEA LEVEL

295.20 5.10 295.00 4.90 4.80 4.70 4.60 4.50 4.40 4.30 4.20 4.10 294.00 3.90 3.80 3.70 3.60 3.50 3.40 3.30 3.20 3.10 293.00 2.90 2.80 2.70 2.60 2.50 2.40 2.30 2.20 2.10 292.00 1.90 1.80 291.70

WHIRLPOOL
DATA USED

Group	Number of observations	Elevation of Water Whirlpool Gage	Volume of Discharge
1	10	295.08	233,640
2	10	4.70	226,580
3	10	4.41	224,470
4	10	4.14	223,670
5	10	3.93	224 170
6	10	3.79	221,360
7	10	3.44	218,730
8	10	3.14	214,960
9	10	2.80	210,690
10	10	2.10	207,130
11	8	1.77	203,930
	108	Mean 3.36	219,300

See Report, "PRESERVATION OF NIAGARA FALLS," Page 46, also Page 31.

Note: Group No. 1 contains the ten observations showing the highest elevation of the Whirlpool Gage
Group No. 2 is made up of the next lower ten observations
Group No. 11 contains the eight observations with lowest gage reading
Others are intermediate in order of gage height.

Mean of 11 groups
108 discharge observations

UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO
THE VOLUME OF DISCHARGE
OF THE NIAGARA RIVER
PLOTTED WITH RESPECT TO
THE ELEVATION OF THE
WATER SURFACE
AT THE
WHIRLPOOL
GAGE

Equation of Discharge: $Q = 188,740.8585(R_w - 290.00)$
Increment at Whirlpool is 8585.
Derived Increment for Lake Erie is $8585 \times 2.61 = 22,400$
The multiplier 2.61 is the ratio of fluctuation of the Whirlpool compared with Lake Erie at Cleveland, Ohio. See Exhibit H, Shenehon, April 15, 1914.
Lowerings of Lake Erie indicated by Derived Increment, are as follows

For Diversion at Chicago of 10,000 cu. sec ft. 5 3/4 inches
4,000 " " " 2 1/2 "
14,000 " " " 7 3/4 "

These conclusions are entirely independent of the Buffalo Gage readings during the observations for Volume of Discharge

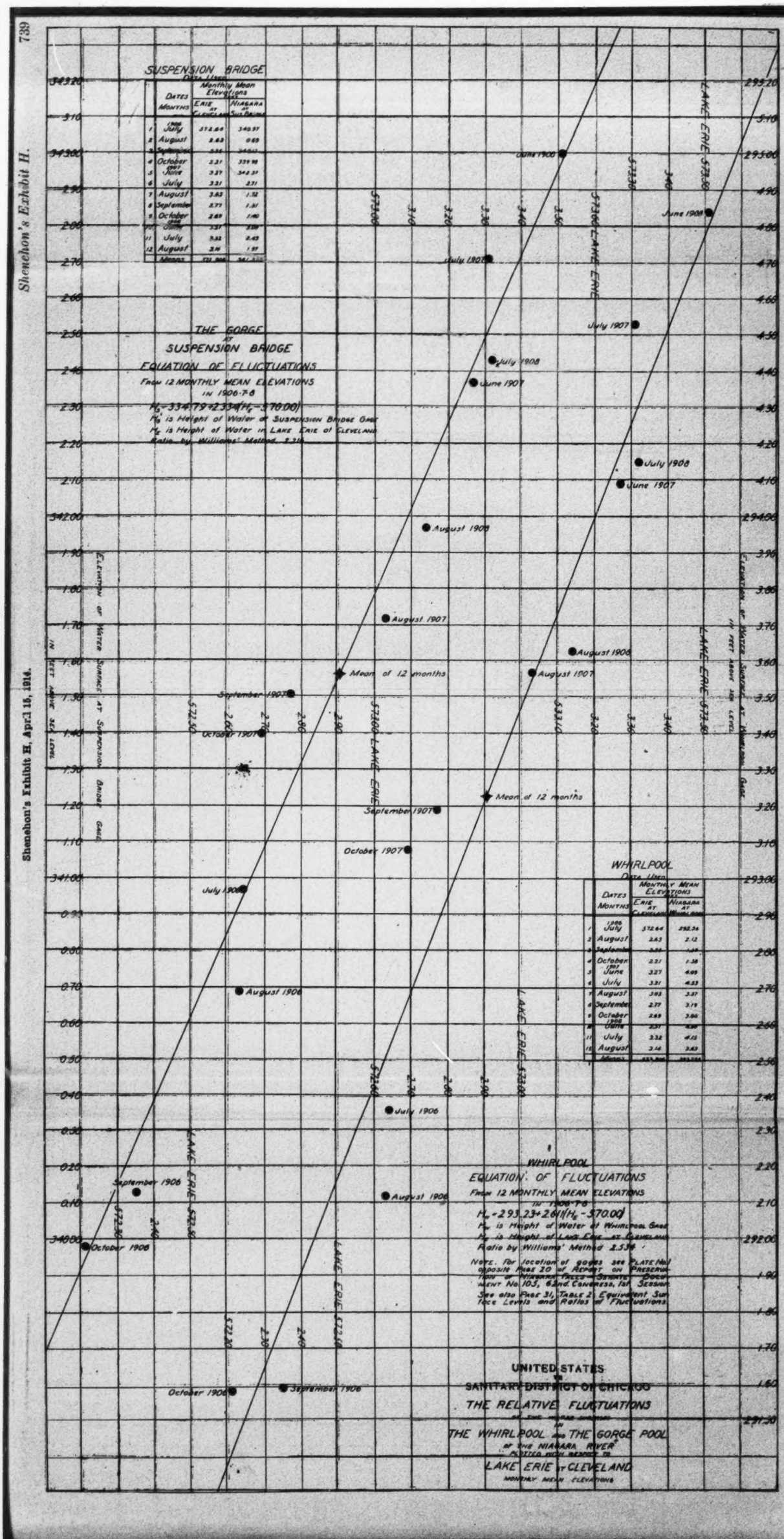
M.E. Souther, Del
DEC 1913

VOLUME OF DISCHARGE
IN CUBIC SECONDS FEET

739

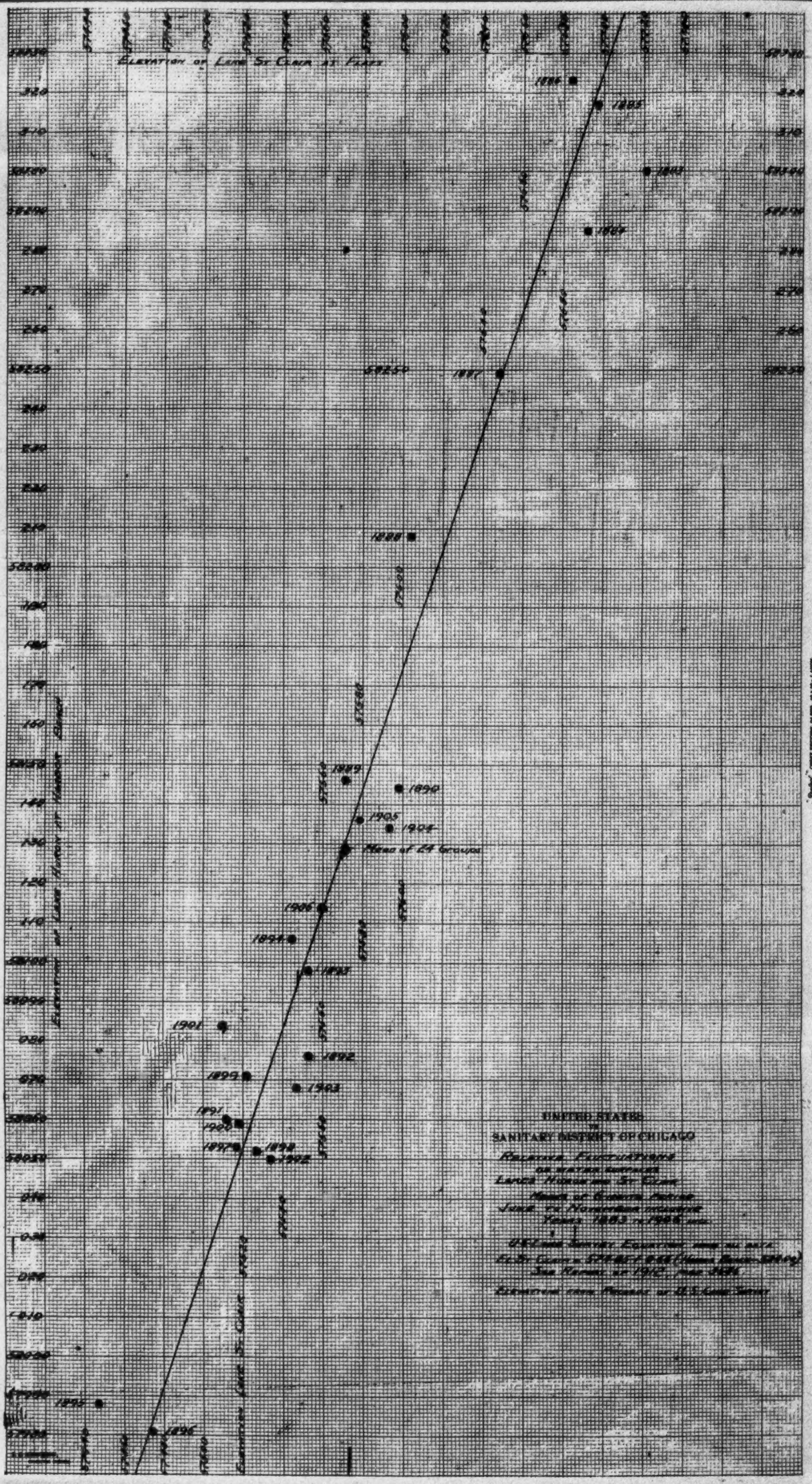
Shenehon's Exhibit H.

Shenehon's Exhibit H, April 15, 1914.

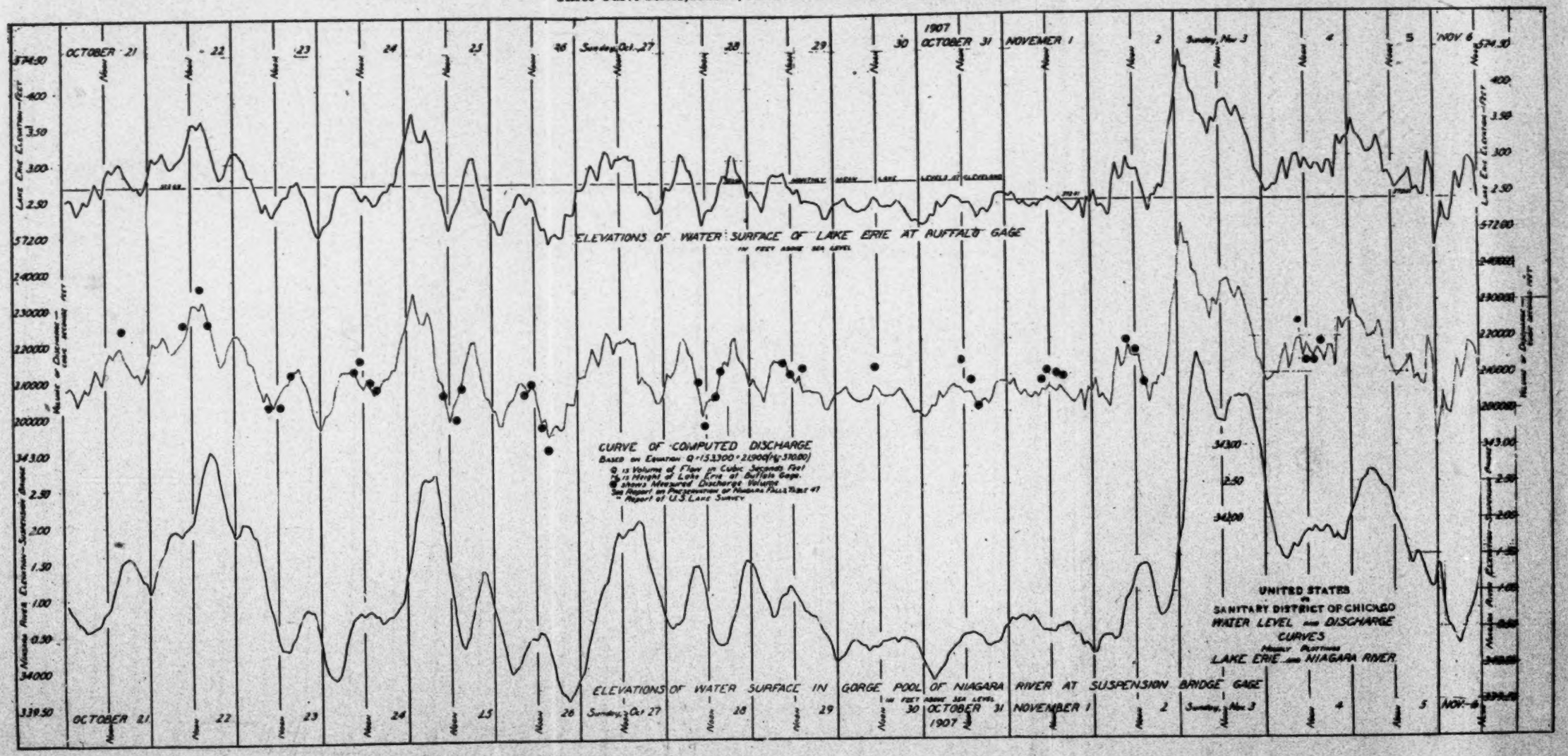


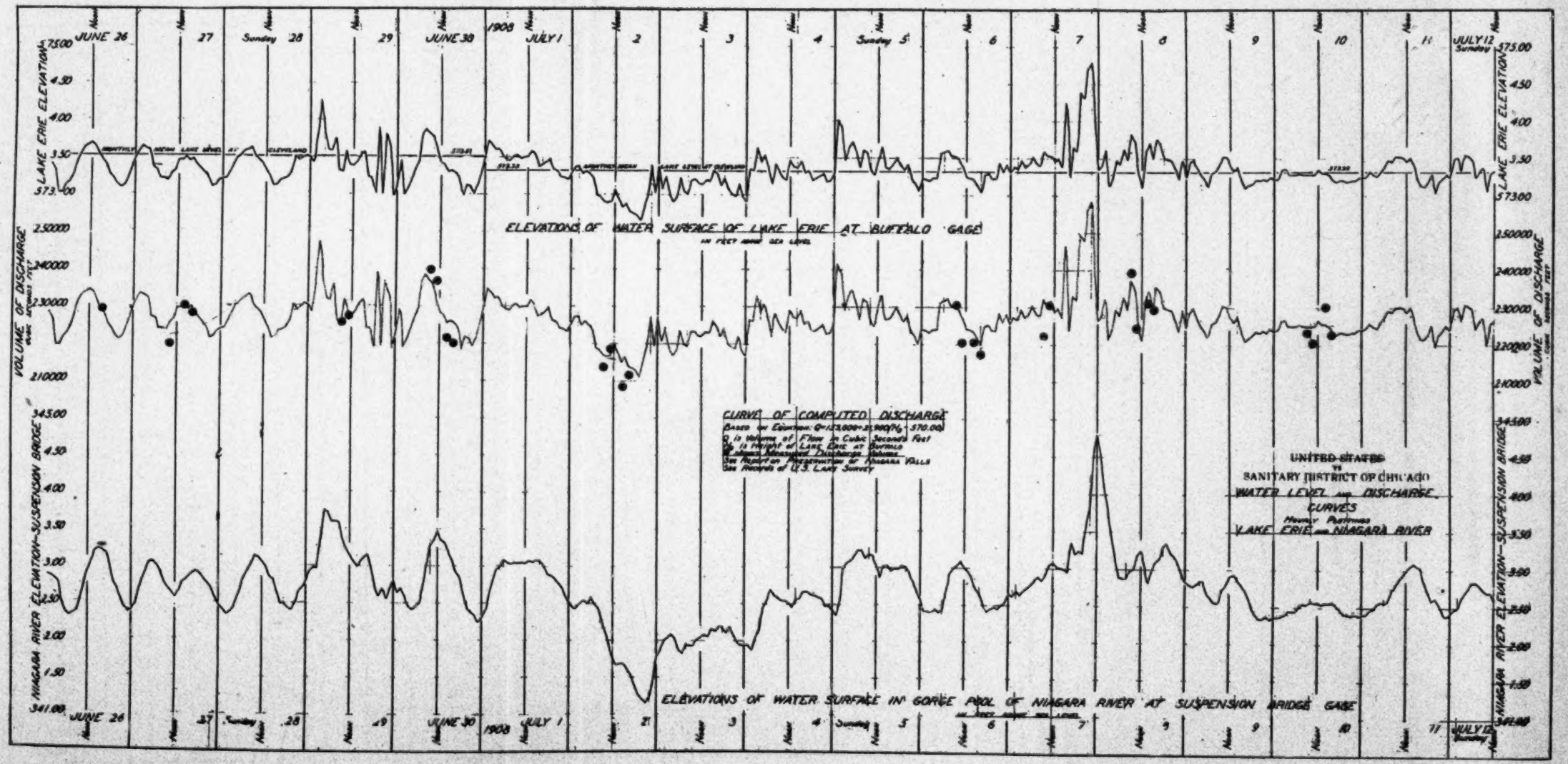
Shenehon's Exhibit I.

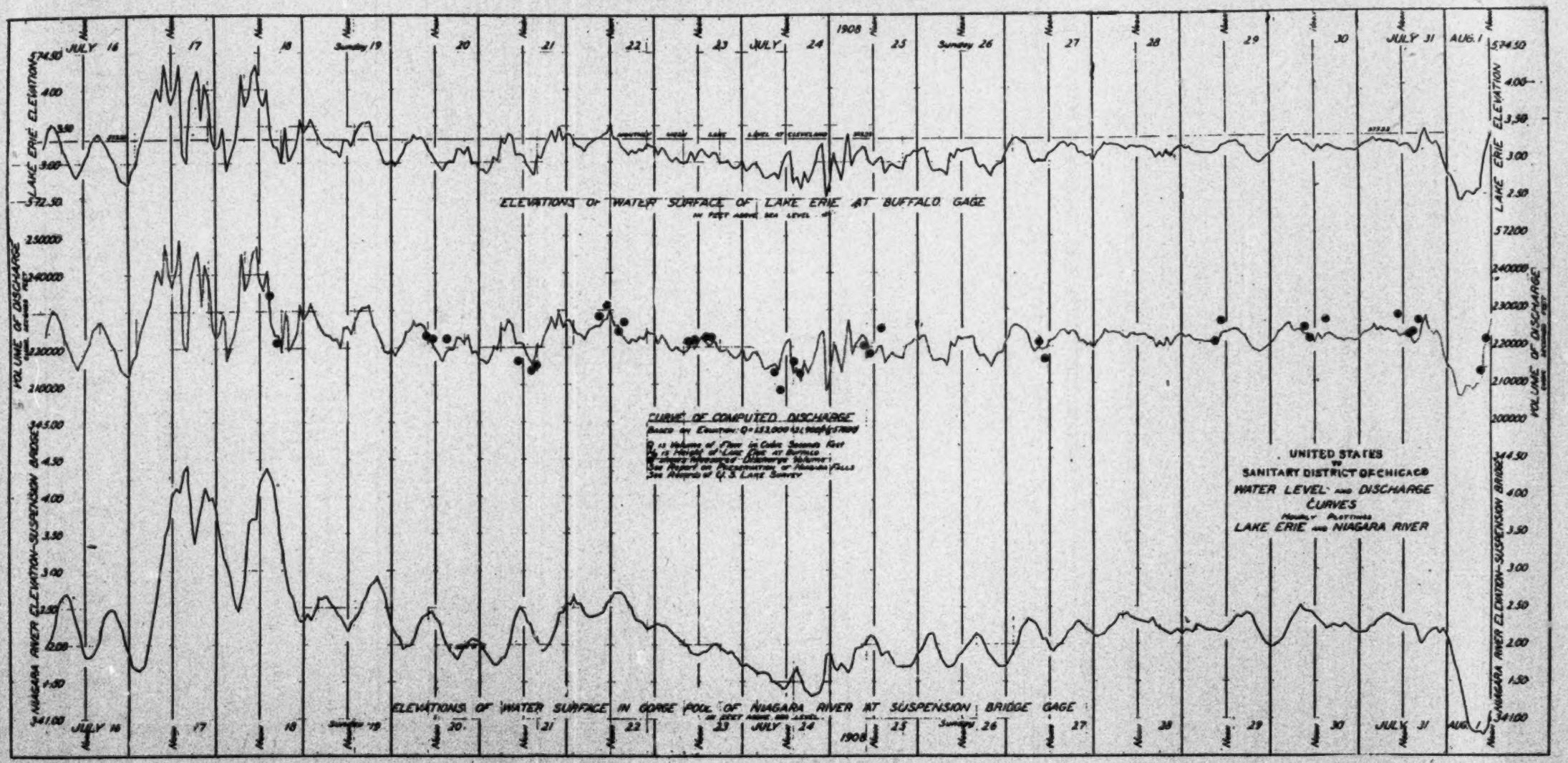
Shenehon's Exhibit I, April 15, 1914.



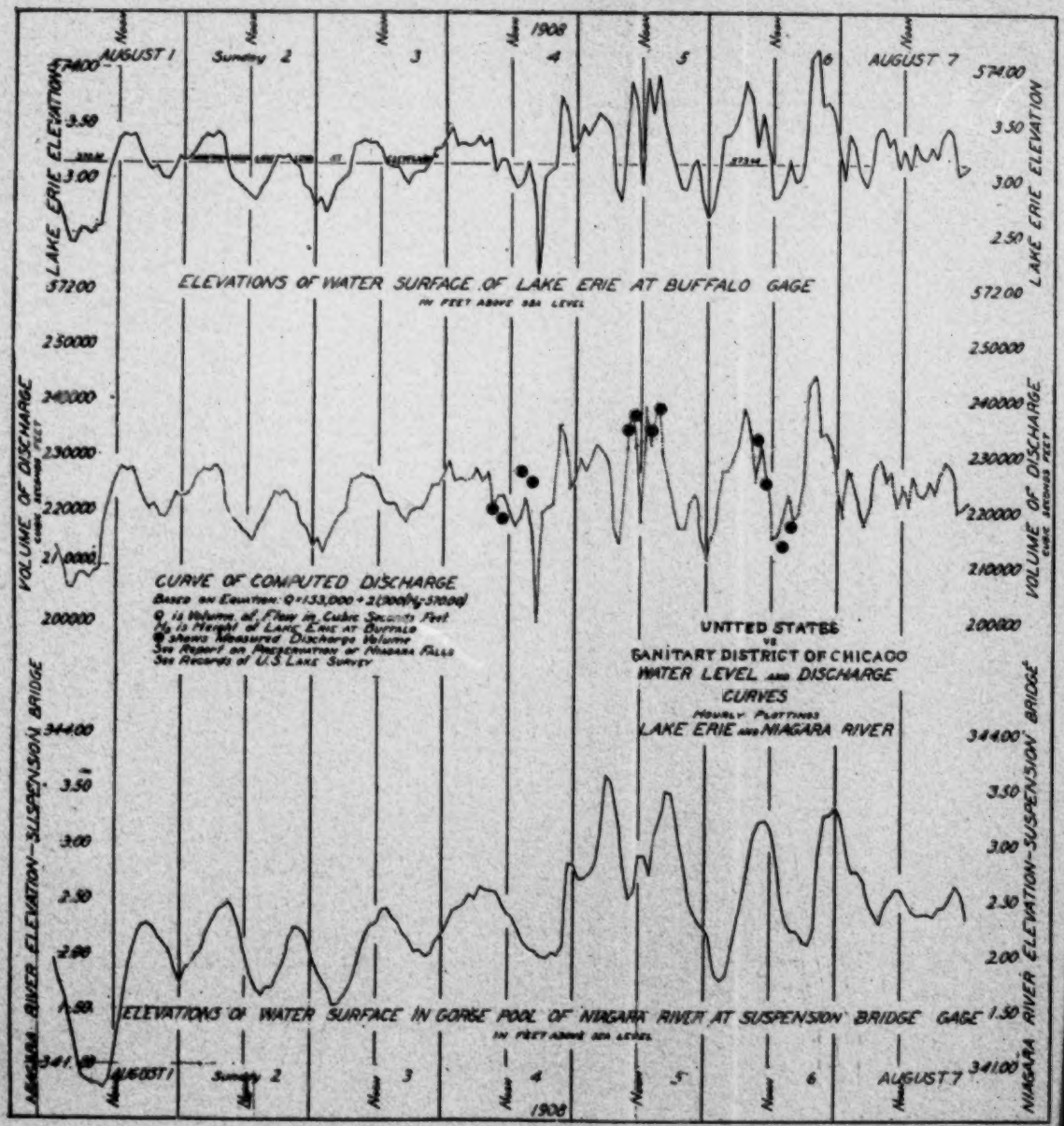
Three-Curve Series, Sheet 1, Shenehon's Exhibit K, April 15, 1914.

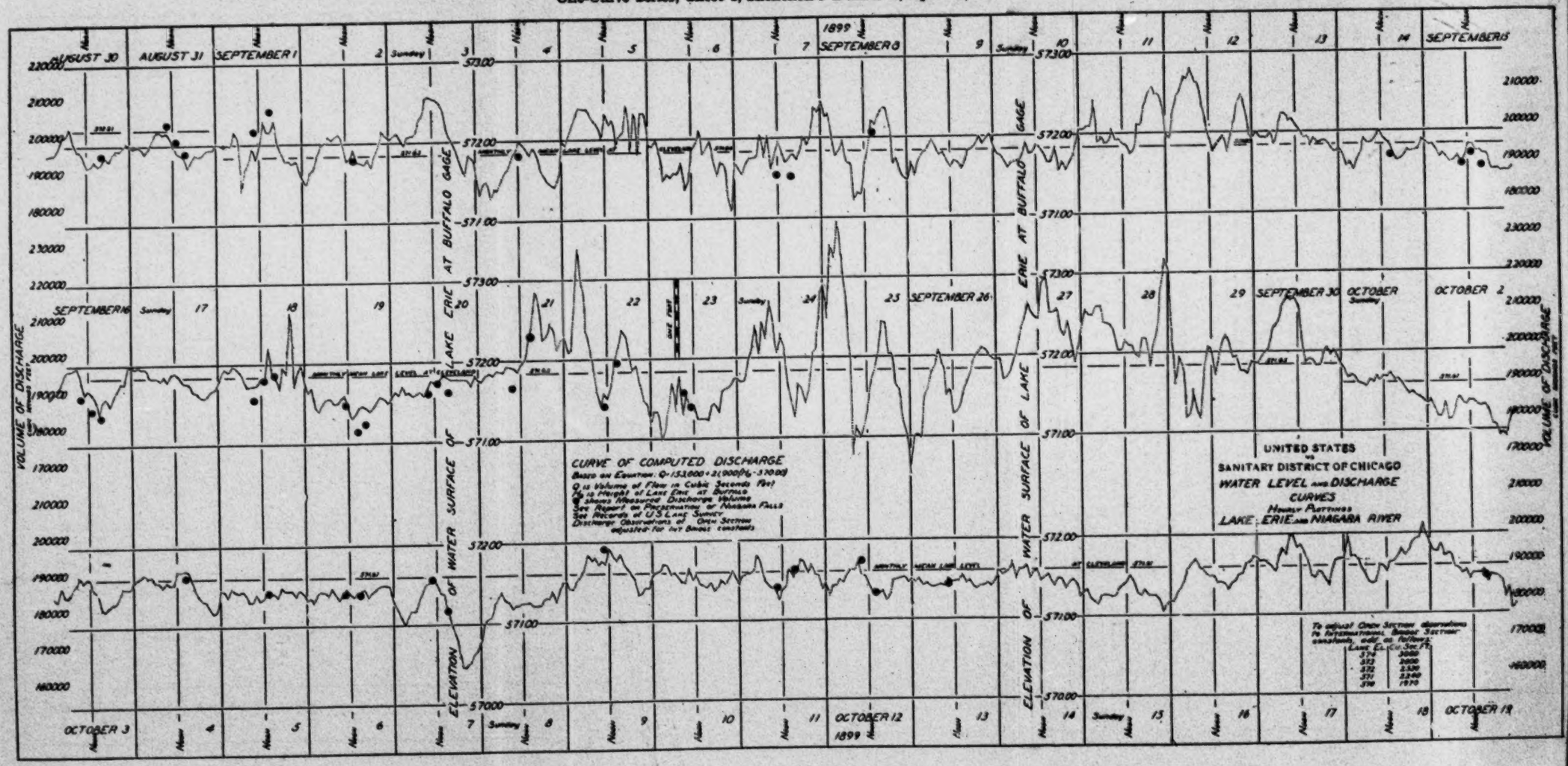


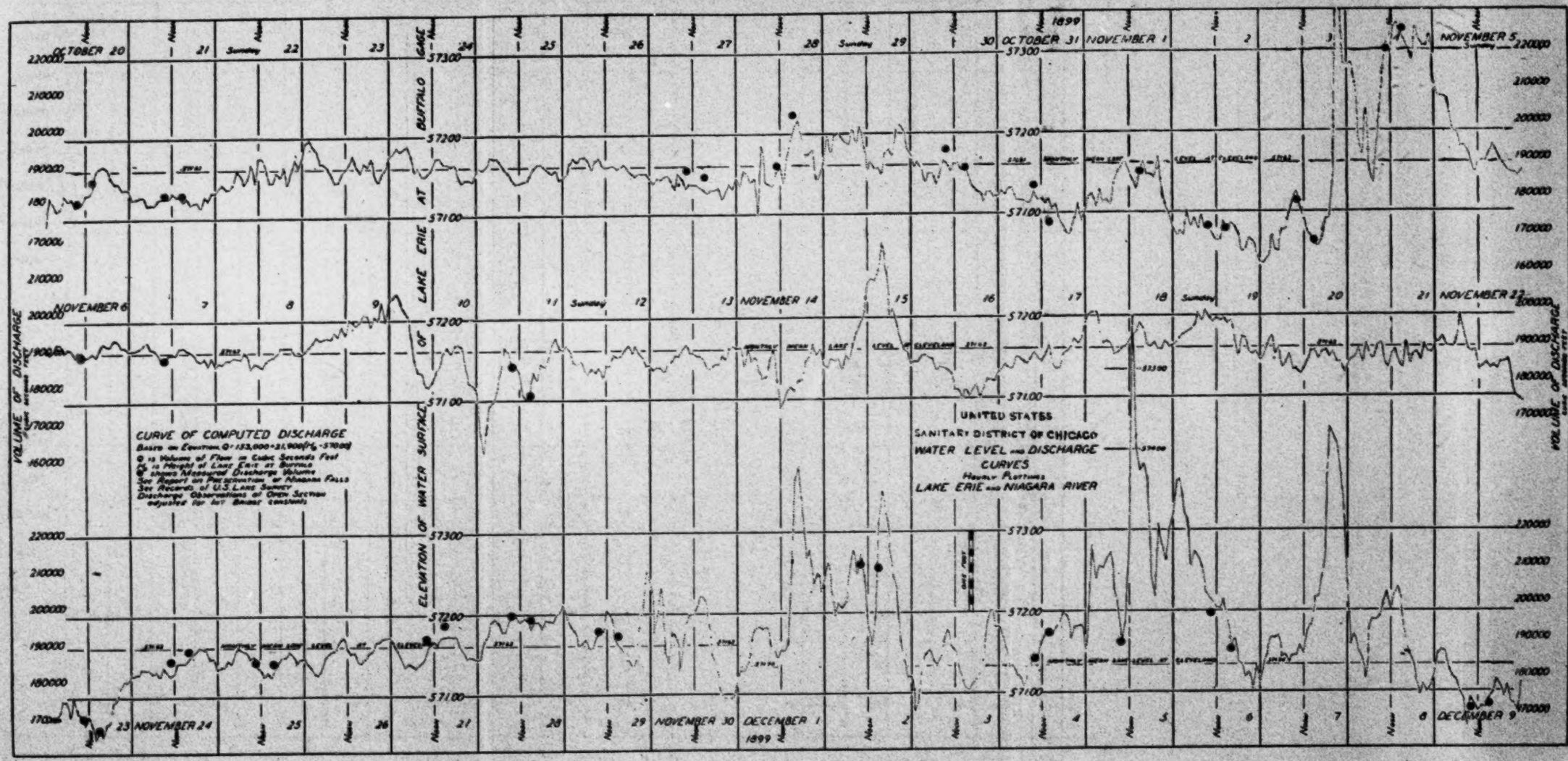

JUNE 26
27
Sunday 28
29
JUNE 30
1908
JULY 1
2
3
4
Sunday 5
6
7
8
9
10
11
JULY 12
Sunday
LAKE ERIE ELEVATION
573.00
VOLUME OF DISCHARGE
250000
240000
230000
220000
210000
NIAGARA RIVER ELEVATION-SUSPENSION BRIDGE
345.00
341.00
ELEVATIONS OF WATER SURFACE OF LAKE ERIE AT BUFFALO GAGE
CURVE OF COMPUTED DISCHARGE
UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO
WATER LEVEL and DISCHARGE
CURVES
Hourly Postings
LAKE ERIE and NIAGARA RIVER
ELEVATIONS OF WATER SURFACE IN GORGE POOL OF NIAGARA RIVER AT SUSPENSION BRIDGE GAGE

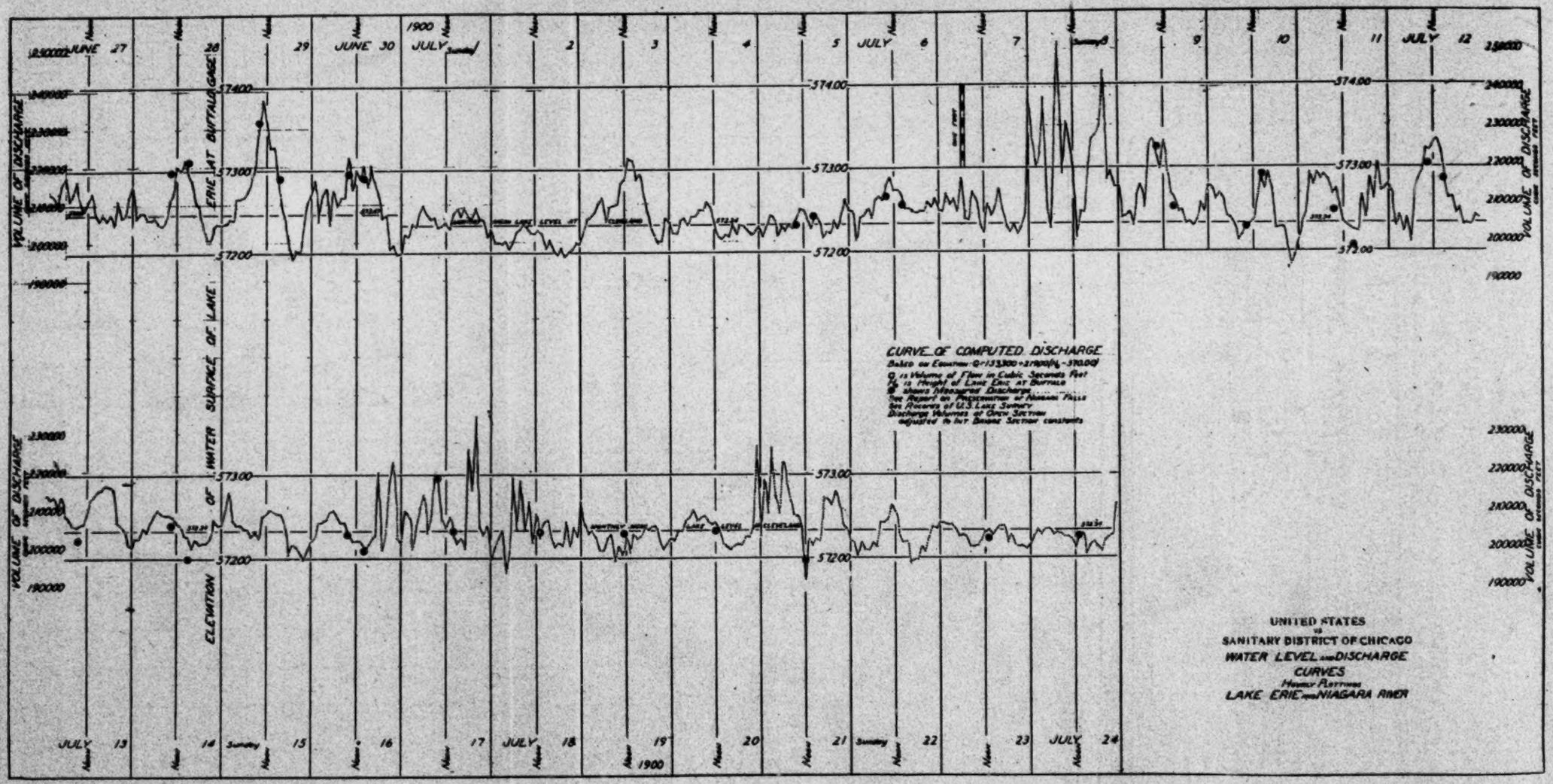

ELEVATIONS OF WATER SURFACE OF LAKE ERIE AT BUFFALO GAGE
CURVE OF COMPUTED DISCHARGE
ELEVATIONS OF WATER SURFACE IN GORGE POOL OF NIAGARA RIVER AT SUSPENSION BRIDGE GAGE
UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO
WATER LEVEL and DISCHARGE
CURVES
Hourly Plottings
LAKE ERIE and NIAGARA RIVER
LAKE ERIE ELEVATION
VOLUME OF DISCHARGE
NIAGARA RIVER ELEVATION-SUSPENSION BRIDGE
JULY 16
17
18
19
20
21
22
23
JULY 24
1908
25
26
27
28
29
30
JULY 31
AUG. 1

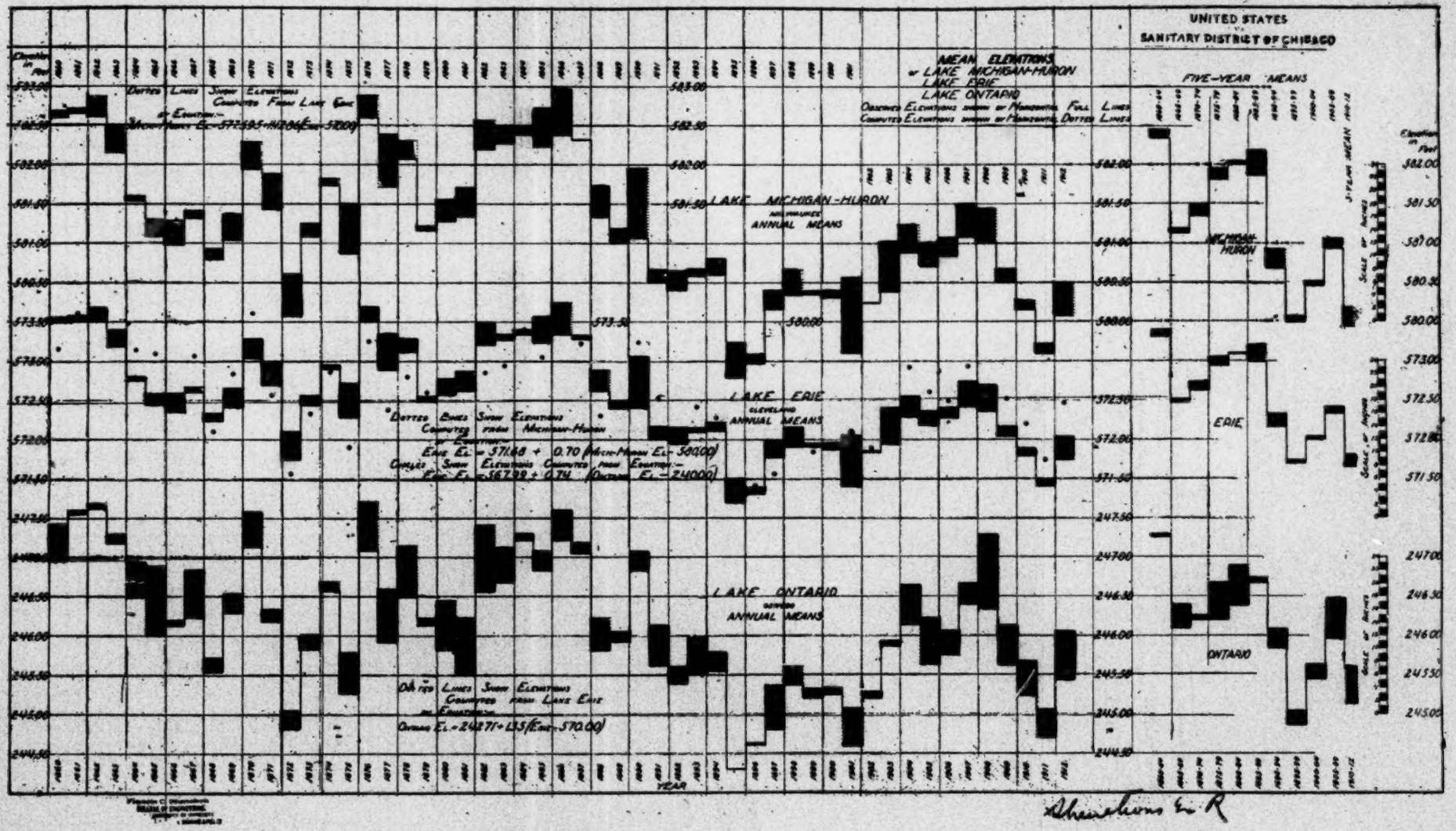
Three-Curve Series, Sheet 4, Shenehon's Exhibit N, April 15, 1914.

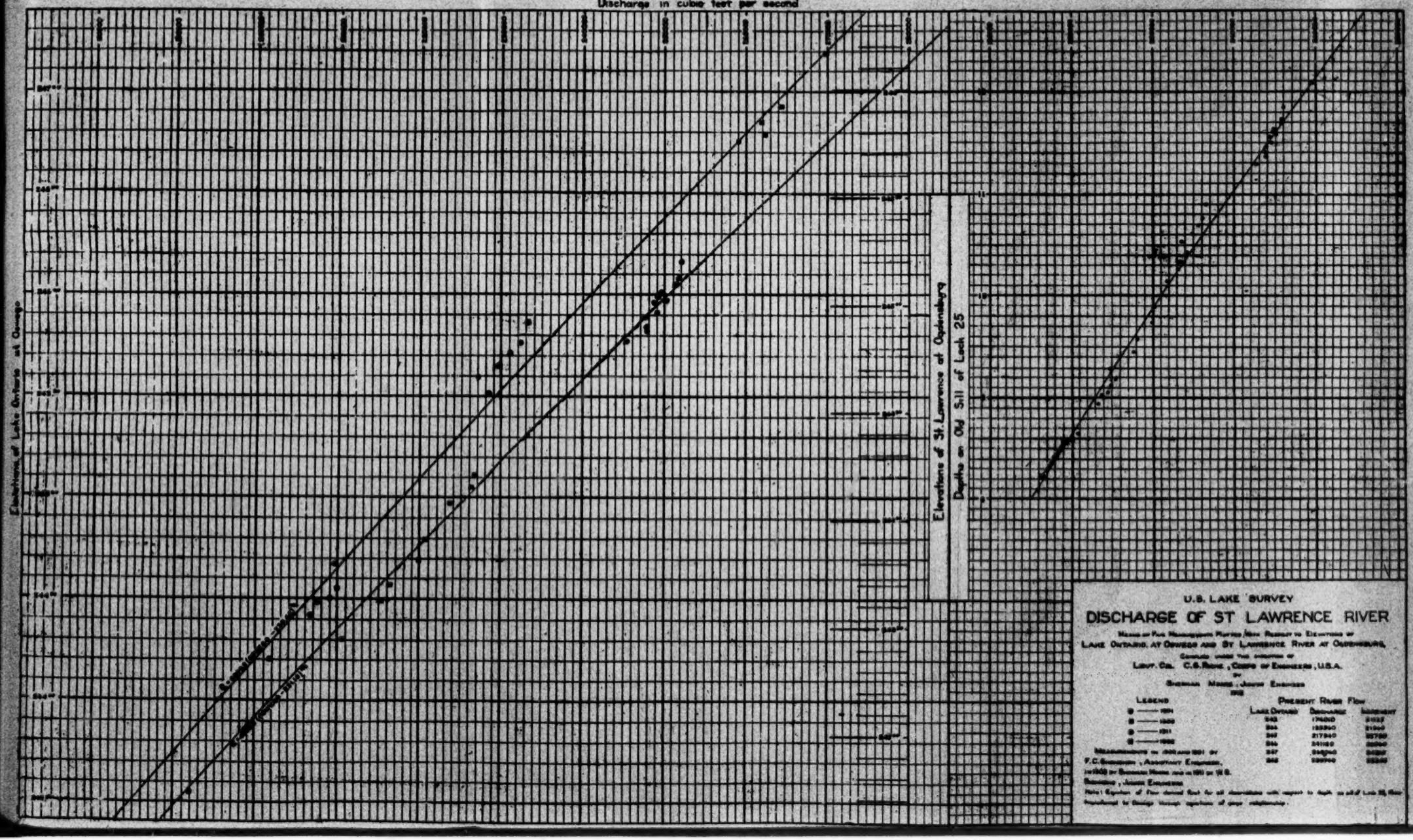



VOLUME OF DISCHARGE
ELEVATION OF WATER SURFACE OF LAKE ERIE AT BUFFALO GAGE
AUGUST 30
AUGUST 31
SEPTEMBER 1
SEPTEMBER 16
SEPTEMBER 26
SEPTEMBER 30
OCTOBER 2
OCTOBER 3
OCTOBER 12
OCTOBER 19
1899
CURVE OF COMPUTED DISCHARGE
Based on Equation: Q=153,000+2(900Ph-3900)
Q is Volume of Flow in Cubic Seconds Feet
Ph is Height of Lake Erie at Buffalo
Above Measured Discharge Volume
See Report on Preservation of Niagara Falls
See Records of U.S. Lake Survey
Discharge Observations of Open Section adjusted for Ice Sheet conditions
UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO
WATER LEVEL and DISCHARGE CURVES
Hourly Plottings
LAKE ERIE and NIAGARA RIVER


VOLUME OF DISCHARGE
ELEVATION OF WATER SURFACE OF LAKE ERIE AT BUFFALO GAGE
OCTOBER 20
NOVEMBER 6
NOVEMBER 23
NOVEMBER 24
NOVEMBER 30
DECEMBER 1
1899
OCTOBER 31
NOVEMBER 1
NOVEMBER 5
NOVEMBER 22
DECEMBER 9
CURVE OF COMPUTED DISCHARGE
UNITED STATES
SANITARY DISTRICT OF CHICAGO
WATER LEVEL and DISCHARGE CURVES
Hourly Plottings
LAKE ERIE and NIAGARA RIVER


JUNE 27
28
29
JUNE 30
JULY
2
3
4
5
JULY 6
7
9
10
11
JULY 12
1900
574.00
573.00
572.00
VOLUME OF DISCHARGE
ELEVATION OF WATER SURFACE OF LAKE ERIE AT BUFFALO GAGE
CURVE OF COMPUTED DISCHARGE
Based on Equation: Q=13,300 (H-570.00)²
Q is Volume of Flow in Cubic Seconds Feet
H is Height of Lake Erie at Buffalo
● shows Measured Discharge
See Report on Regulation of Niagara Falls
See Records of U.S. Lake Survey
Discharge Volumes of Open Section
adjusted to Int Bridge Section constants
JULY 13
14
15
16
17
JULY 18
19
20
21
22
23
JULY 24
UNITED STATES
vs
SANITARY DISTRICT OF CHICAGO
WATER LEVEL and DISCHARGE
CURVES
Hourly Readings
LAKE ERIE and NIAGARA RIVER


UNITED STATES
SANITARY DISTRICT OF CHICAGO
MEAN ELEVATIONS
OF LAKE MICHIGAN-HURON
LAKE ERIE
LAKE ONTARIO
FIVE-YEAR MEANS
LAKE MICHIGAN-HURON
ANNUAL MEANS
LAKE ERIE
ANNUAL MEANS
LAKE ONTARIO
ANNUAL MEANS
MICHIGAN-HURON
ERIE
ONTARIO
YEAR


Discharge in cubic feet per second
Elevations of Lake Ontario at Oswego
Elevations of St. Lawrence at Ogdensburg
Depths on Obj Sill of Lock 25
U.S. LAKE SURVEY
DISCHARGE OF ST LAWRENCE RIVER
LEGEND
PRESENT RIVER FLOW

Shenehon's Exhibit T, April 15, 1914.

U.S. vs SANITARY DISTRICT
COMPARISON OF
ST LAWRENCE AND NIAGARA RIVER DISCHARGES
WITH INTERMEDIATE SUPPLY
COMPUTED BY DEFENDANT'S WITNESS STEARNS

1	2	3	4	5	6	7
JUNE TO NOV YEAR	DISCHARGE BY ST LAWRENCE RIVER C.S.F.	LOCAL SUPPLY AND STORAGE ONTARIO C.S.F.	REDUCED NIAGARA DISCHARGE C.S.F.	ACTUAL NIAGARA DISCHARGE C.S.F.	Col 4 minus Col 5	
1891	244800	45300	199500	204300	− 4800	
2	247600	23400	224200	219800	+ 4400	
3	261300	37400	223900	214700	+ 9200	
4	246700	34100	212600	210400	+ 2200	
1895	205200	25900	179300	186800	− 7500	
6	217500	29900	187600	194800	− 7200	
7	229000	23500	205500	205300	+ 200	
8	235000	28800	206200	207800	− 1600	
9	231300	24400	206900	199400	+ 7500	
1900	232500	29500	203000	202000	+ 1000	
1	230400	31200	199200	192000	+ 7200	
2	241200	22800	218400	207800	+10600	
3	252700	32100	220600	212100	+ 8500	
4	272500	31300	241200	220500	+20700	
1905	253700	22500	233200	218100	+15100	
6	241700	25800	215900	208200	+ 7700	
16 YEARS	240300	29200	211100	206500	+ 4600	

COLUMN 2 ST. LAWRENCE RIVER OUTFLOW BY U.S. LAKE SURVEY 1912 REPORT

COLUMN 3 TOTAL LOCAL SUPPLY AND STORAGE COMPUTED BY MR FREDERIC P. STEARNS SEE HIS TABLE D, COLUMN 3.

COLUMN 5 NIAGARA INFLOW BY U.S. EXHIBIT No 3 TO VOLUME OF RIVER FLOW IS 4000 TO 2300 C.S.F. FOR INFLOW BY ERIE AND WELLAND CANALS.

SHENEHON'S EXHIBIT U 1 April 16, 1914 [5 sheets (1)]

Also HAYFORD'S EXHIBIT 1 for identification of April 10, 1914

FRANCIS C. SHENEHON
Member American Society of Civil Engineers
Consulting Engineer
Minneapolis

NIAGARA RIVER—DISCHARGE

Solution of Straight Line Eq. by Williams 3-point Method

Center of Gravity of 219 observations
Buffalo Gage = 572,549 Thoroughly
Q = 208,952 checked
F.C.S.

See Special Sheet

Center of Gravity of 121 observations

$$\text{Gage} = \frac{377.16}{121} + 570.00 = 573.117$$

$$Q = \frac{26787200}{121} = 221,380$$

Log 377.16 = 2.5765256
Log 121 = 2.0827854
Log 3.117 = 0.4937402

Log 26787200 = 7.4279273
Log 121 = 2.0827854
221,380 = 5.3451419

Center of Gravity of 98 observations

$$\text{Gage} = \frac{180.98}{98} + 570 = 571.847$$

$$Q = \frac{18973400}{98} = 193606$$

Log 180.98 = 2.2576306
Log 98 = 1.9912261
Log 1.847 = 0.2664045

Log 18973400 = 7.2781452
Log 98 = 1.9912261
Log 193,606 = 5.2869191

SHENEHON'S EXHIBIT U 2 April 16, 1914 [5 sheets (2)]

Also HAYFORD'S EXHIBIT 2 for identification of April 10, 1914

FRANCIS C. SHENEHON
Member American Society of Civil Engineers
Consulting Engineer
Minneapolis

Three Point Method
Niagara Discharge

	Gage	Q = Volume		Increment
Upper	573,117	221,380		
c =	0.568	12428	=	21,880
Mean	572,549	208,952		
	0.702	15,346	=	21,860
Lower	571,847	193,606		
		Upper Minus lower =		21,870

Log 12428 = 4.0944012
Log 0.568 = 9.7543483 — 10

Log Inc. 21,880 = 4.3400529

Log 15346 = 4.1859952
Log 0.702 = 9.8463371 — 10

21.860 = 4.3306581

Full Length Upper Minus Lower
Log 27774 = 4.4436384
Log 1.270 = 0.1039037 — 10

21870 = 4.3396347

SHENEHON'S EXHIBIT U 3, April 16, 1914. [5 sheets (3)]
Also HAYFORD EXHIBIT 3, for identification of April 10, 1914

FRANCIS C. SHENEHON

Member American Society of Civil Engineers
Consulting Engineer
Minneapolis

	No. of Dis		
1898—1899—1.01		202.90	198,762.00
1907—1908—1.18		355.24	258,844.00
2.19		558.14	457,606.00
Mean	=	572.55	209000

Log 558.14 = 2.7467431
Log 219 = 2.3404441

Log Gage 2.5486 = 0.4062990
572.549
Log 45760600 = 7.6604917
Log 219 = 2.3404441

Log Q = 208,952 = 5.3200476

Result
Center of Gravity of 219 Observations for Discharge Int. Bridge Niagara River
Gage = 572.549
Q = 208,952

SHENEHON'S EXHIBIT U 4, April 16, 1914. [5 sheets (4)]
Also HAYFORD EXHIBIT 4 for identification of April 10, 1914
FRANCIS C. SHENEHON
Member American Society of Civil Engineers
Consulting Engineer
Minneapolis

3.92	24.09	3.16	21.64		
3.80	23.80	3.15	22.18	2.66	21.39
3.88	23.86	3.15	22.68	2.65	21.05
3.80	23.94	3.12	22.64	2.64	20.07
3.77	23.46	3.12	22.58	2.64	21.08
3.71	23.98	3.11	22.64	2.64	21.25
3.70	23.13	3.10	22.10	2.63	21.14
3.69	23.43	3.10	22.25	2.61	20.96
3.69	23.45	3.09	22.27	2.61	21.12
3.63	23.11	3.08	21.52	2.57	20.21
3.61	23.73	3.08	22.20	2.57	20.58
3.60	23.67	3.08	22.33	2.57	21.51
3.56	23.30	3.08	22.50	2.56	21.37
3.54	22.21	3.07	21.74		
3.54	22.95	3.07	22.13		
3.54	23.04	3.06	22.71		
3.54	23.56	3.05	21.94		
3.52	23.07	3.03	21.72		
3.49	22.98	3.02	22.12		
3.48	22.78	3.01	21.44		
3.46	22.43	3.01	22.12		
3.42	23.12	3.00	21.67		
3.40	22.15	3.00	21.83		
3.39	22.70	3.00	21.88		
3.39	22.88	3.00	22.16		
3.39	23.18	3.00	22.23		
3.39	23.48	3.00	22.47		
3.38	22.82	2.98	22.41		
3.37	22.57	2.98	22.52		
3.34	22.04				
3.33	22.92	2.97	21.76		
3.32	22.55	2.94	21.38		
3.30	22.34	2.93	21.58		
3.30	23.02	2.92	21.36		
3.29	22.41	2.91	21.39		
3.28	21.90	2.91	21.87		
3.28	22.00	2.87	20.85		
3.27	22.05	2.87	21.34		
3.27	22.50	2.86	21.34		
3.24	22.31	2.85	20.84		
3.23	22.66	2.85	21.61		
3.23	22.28	2.84	21.31		
3.21	22.15	2.84	21.67		
3.21	22.48	2.82	21.36		
3.20	22.04	2.82	21.52		
3.20	22.28	2.81	21.32		
3.20	22.68	2.81	21.48		
3.20	22.79	2.80	21.94		
3.19	22.26	2.79	21.49		
3.18	21.87	2.77	21.17		
3.18	22.04	2.73	21.25		
3.18	22.67	2.72	21.30		
		2.72	21.33		
		2.71	20.73		
		2.70	20.80		
		2.69	21.50		
		2.67	21.30		
		2.67	21.40		
			21.20		
			21.05		
			21.25		
			21.05		
			20.67		

8mm Gage = 377.16
Volume = 267862
N = 121

SHENEHON'S EXHIBIT U 5, April 16, 1914. [5 sheets (5).]

Also HAYFORD EXHIBIT 5 for identification of April 10, 1914.

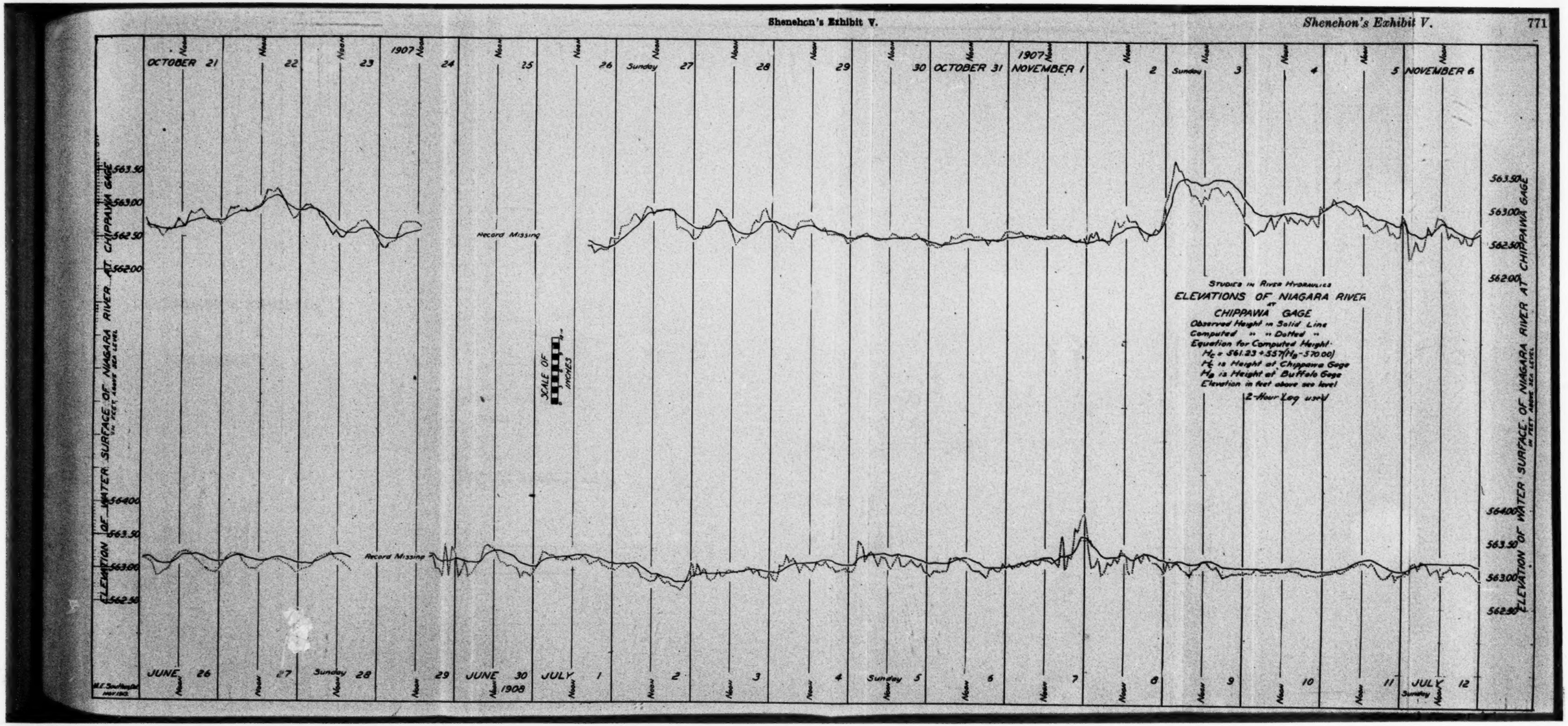
NIAGARA DISCHARGE.

1898-99

FRANCIS C. SHENEHON
Member American Society of Civil Engineers
Consulting Engineer, Minneapolis.

uffalo Gage*	Q*	Gage	Q
2.55	20.78	1.76	19.01
2.54	20.71	1.75	19.04
2.54	20.92	1.74	19.24
2.52	20.76	1.74	18.85
2.52	20.85	1.73	18.74
2.50	21.56	1.73	18.88
2.49	20.55	1.72	18.89
2.48	20.82	1.70	18.91
2.48	20.84	1.68	19.22
2.46	20.88	1.66	18.80
2.45	21.41	1.66	18.90
2.44	21.24	1.66	19.35
2.42	20.25	1.65	18.87
2.42	20.62	1.65	19.00
2.41	20.72	1.64	19.04
2.40	20.16	1.63	18.81
2.40	21.11	1.61	18.49
2.39	20.29	1.61	18.97
2.39	20.61	1.60	18.80
2.39	21.02	1.57	18.85
2.38	20.83	1.56	18.65
2.38	20.86	1.54	18.75
2.38	20.98	1.53	18.69
2.37	20.51	1.48	18.48
2.35	19.89	1.47	18.76
2.35	20.42	1.46	18.85
2.35	20.69	1.45	18.06
2.33	20.24	1.44	18.29
2.32	20.10	1.44	18.57
2.32	20.83	1.43	18.35
2.29	20.71	1.42	18.19
2.26	20.37	1.41	18.02
2.24	20.66	1.41	18.22
2.21	19.75	1.14	18.32
2.19	20.16	1.02	17.56
2.16	19.89	.79	17.38
2.13	19.62	.64	16.92
2.10	19.64	.24	16.16
2.03	19.35	.14	15.72
2.03	19.58	.11	15.56
2.01	19.55	.3	15.45
1.99	19.68	570.00	15.41
1.97	19.58		
1.96	19.50		
1.96	19.50		
1.94	19.00		
1.87	19.71		
1.86	19.49		
1.85	18.89		
1.83	19.30		
1.81	19.26		
1.80	18.89		
1.79	19.13		
1.79	19.17		
1.78	19.38		
1.77	19.11		

Sum Gage = 180.98
* Volume = 18973400
N = 98


OCTOBER 21
22
23
1907
24
25
26
Sunday 27
28
29
30
OCTOBER 31
1907
NOVEMBER 1
2
Sunday 3
4
5
NOVEMBER 6
Noon
Record Missing
Record Missing
SCALE OF INCHES
STUDIES IN RIVER HYDRAULICS
ELEVATIONS OF NIAGARA RIVER AT CHIPPAWA GAGE
Observed Height in Solid Line
Computed " " Dotted "
Equation for Computed Height:
$H_C = 561.23 + .557(H_B - 570.00)$
H_C is Height at Chippawa Gage
H_B is Height at Buffalo Gage
Elevation in feet above sea level
2-Hour Log w.s.w.
ELEVATION OF WATER SURFACE OF NIAGARA RIVER AT CHIPPAWA GAGE
IN FEET ABOVE SEA LEVEL
563.50
563.00
562.50
562.00
564.00
563.50
563.00
562.50
JUNE 26
27
Sunday 28
29
JUNE 30
1908
JULY 1
2
3
4
Sunday 5
6
7
8
9
10
11
JULY 12
Sunday
M.E. Southgate
NOV 1913

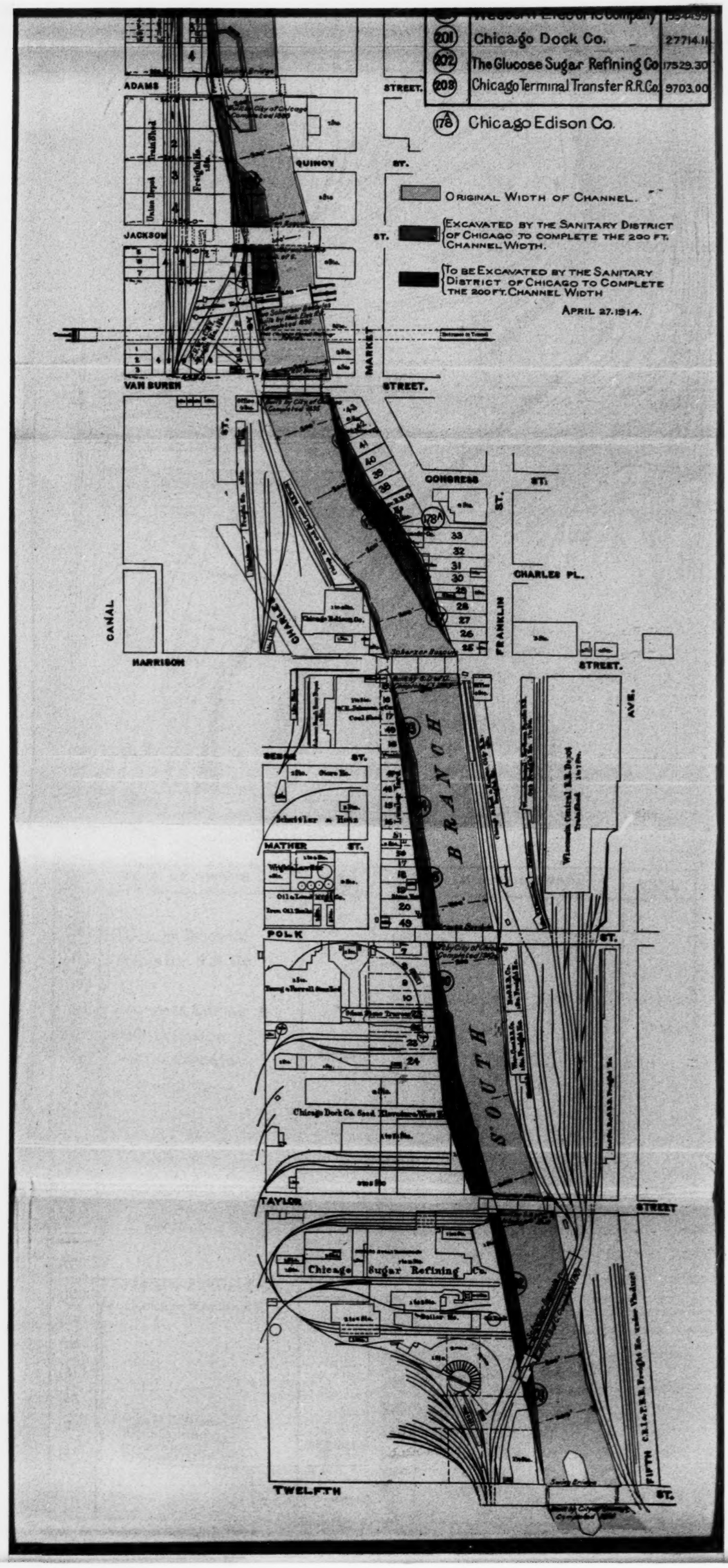
DEFENDANT'S EXHIBITS

IN

SUR-REBUTTAL.

RIVER
WABASH AV
STATE
DEARBORN
CLARK
LASALLE
MICHIGAN AVE.
RUSH
STREET

Wisner's Exhibit 7
May 20. 1914.
WABASH AV.
STATE
DEARBORN
CLARK
LASALLE
FIFTH AVE.
FRANKLIN
SOUTH WATER
WELLS ST.
LAKE
CARROLL
KINZIE
RIVER
CHICAGO
MICHIGAN AVE.
RUSH STREET
STREET


201 Chicago Dock Co. 27714.11
202 The Glucose Sugar Refining Co 17529.30
208 Chicago Terminal Transfer R.R.Co. 9703.00
178 Chicago Edison Co.
ORIGINAL WIDTH OF CHANNEL.
EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH.
TO BE EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH
APRIL 27. 1914.
ADAMS
QUINCY
JACKSON
VAN BUREN
MARKET
STREET.
CONGRESS
CHARLES PL.
FRANKLIN
CANAL
HARRISON
SOUTH BRANCH
MATHER
POLK
TAYLOR
Chicago Sugar Refining Co.
TWELFTH
FIFTH AVE.

775

Wisner's Exhibit 8.

SANITARY DISTRICT OF CHICAGO

MAP

Showing

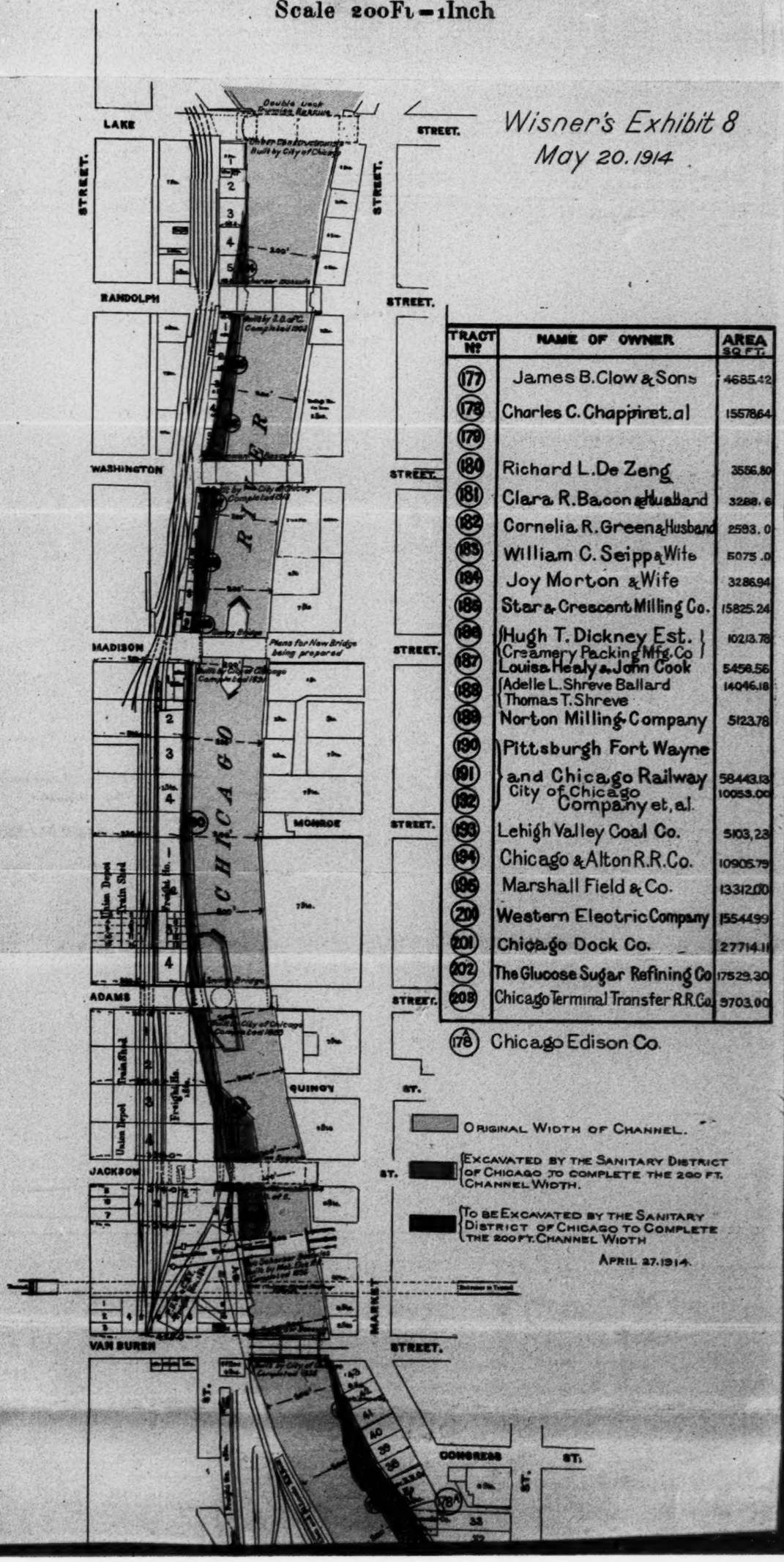
CHICAGO RIVER IMPROVEMENT

From

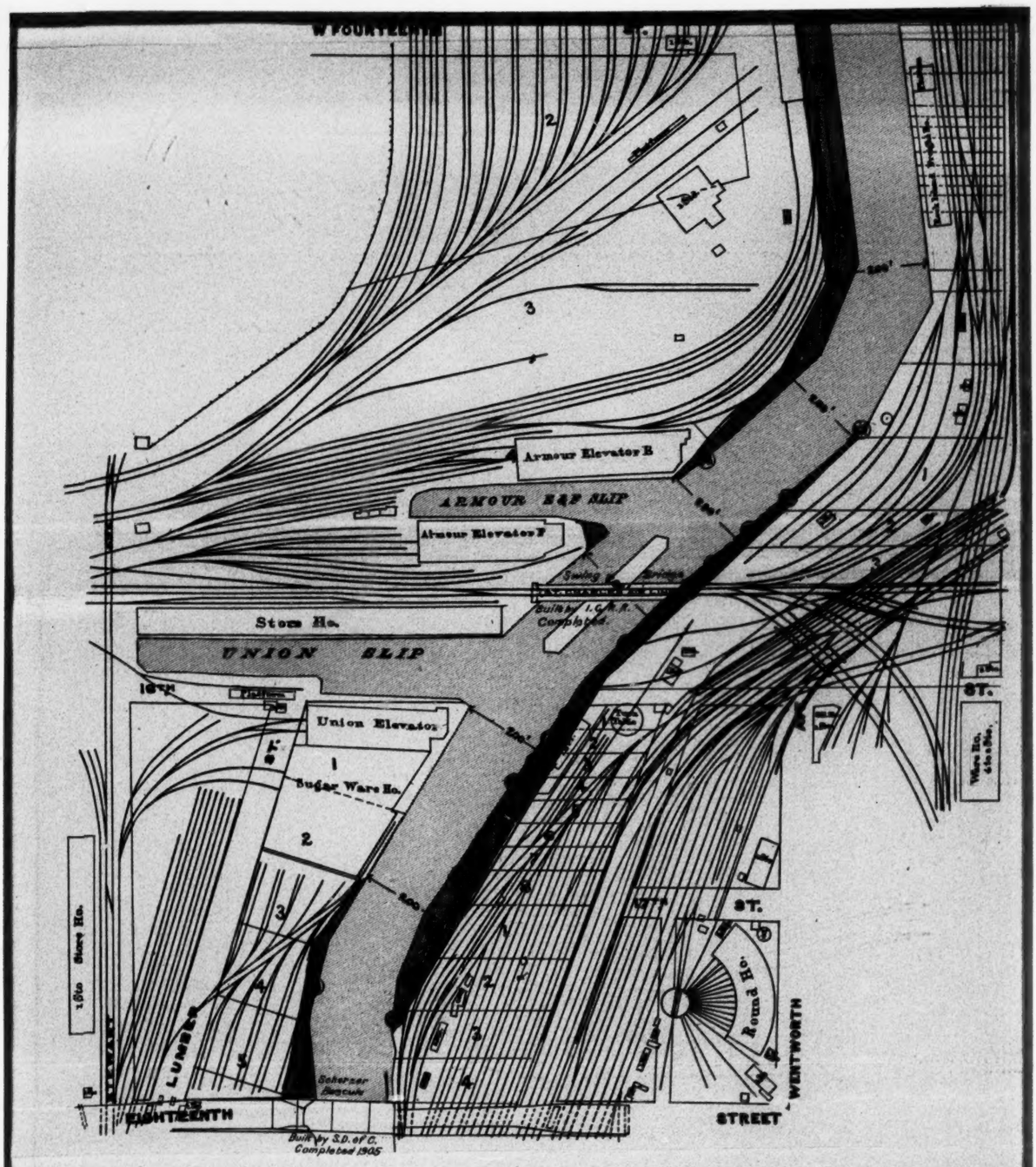
LAKE STREET TO 12TH STREET

Scale 200 Ft = 1 Inch

Wisner's Exhibit 8
May 20. 1914.



TRACT №	NAME OF OWNER	AREA SQ FT.
177	James B. Clow & Sons	4685.42
178	Charles C. Chappiret. al	1557864
179		
180	Richard L. De Zeng	3556.80
181	Clara R. Bacon & Husband	3288. 6
182	Cornelia R. Green & Husband	2583. 0
183	William C. Seipp & Wife	5075 .0
184	Joy Morton & Wife	3286.94
186	Star & Crescent Milling Co.	15825.24
186	Hugh T. Dickney Est.	10213.78
187	Creamery Packing Mfg. Co	
188	Louisa Healy & John Cook	5456.56
	Adelle L. Shreve Ballard	14046.18
	Thomas T. Shreve	
189	Norton Milling Company	5123.78
190	Pittsburgh Fort Wayne	
191	and Chicago Railway	58443.13
192	City of Chicago	10053.00
	Company et. al.	
193	Lehigh Valley Coal Co.	5103.23
194	Chicago & Alton R.R. Co.	10905.79
195	Marshall Field & Co.	13312.00
200	Western Electric Company	1554499
201	Chicago Dock Co.	27714.11
202	The Glucose Sugar Refining Co	17529.30
203	Chicago Terminal Transfer R.R. Co.	9703.00



TRACT No.	NAME OF OWNER	AREA SQ. FT.	TRACT No.	NAME OF OWNER	AREA SQ. FT.
15	Chicago Terminal Transfer R.R. Co.	6,305.95	35	See Tracts 33 & 34 for Owners and Area	
16			36		
17			37A		
18			37	Chicago & North Western Ry. Co	37,772.29
18A	George M. Eckles Edith O. Eckles (City Elevator Property)	11,583.66	38		1,727.20
19			152		
20			153		
21			154		
21A	Chicago Terminal Transfer R.R. Co	12924.63	155		
22			156		
23			157	Chicago & Western Indiana R.R. Co. et al	42,606.80
24			158		
25 N.R. S.R.	Chicago & Great Western R.R. Co. B & O. Chicago Terminal R.R. Co.	31,491.65	159		
26			160		
27			161		
28			162		
29			163	C.R.I. & P.R.R. Co. L.S. & M.S.R'y. Co. & C. & W.R.R. Co	5,410.02 16.03
30			163A	M.C.R.R - I.C.R.R. - C.B. & Q.R.R.	1,768.50
31			164		
32			165	C.R.I. & P.R.R. Co. L.S. & M.S.R'y. Co. C. & W.R.R. Co.	8960.37
33	George M. Eckles Edith O. Eckles (Iowa Elevator Property)	24,004.56	166		
34			167	L.S. & M.S.R.R. Co.	00.78
			39 40	Wm. A. Havemeyer & Rosa R. Havemeyer	5686.00

777

Wisner's Exhibit 9.

SANITARY DISTRICT OF CHICAGO

MAP

Showing

CHICAGO RIVER IMPROVEMENT

From

12TH STREET TO 18TH STREET

Scale 200Ft = 1Inch Wisners Exhibit 9

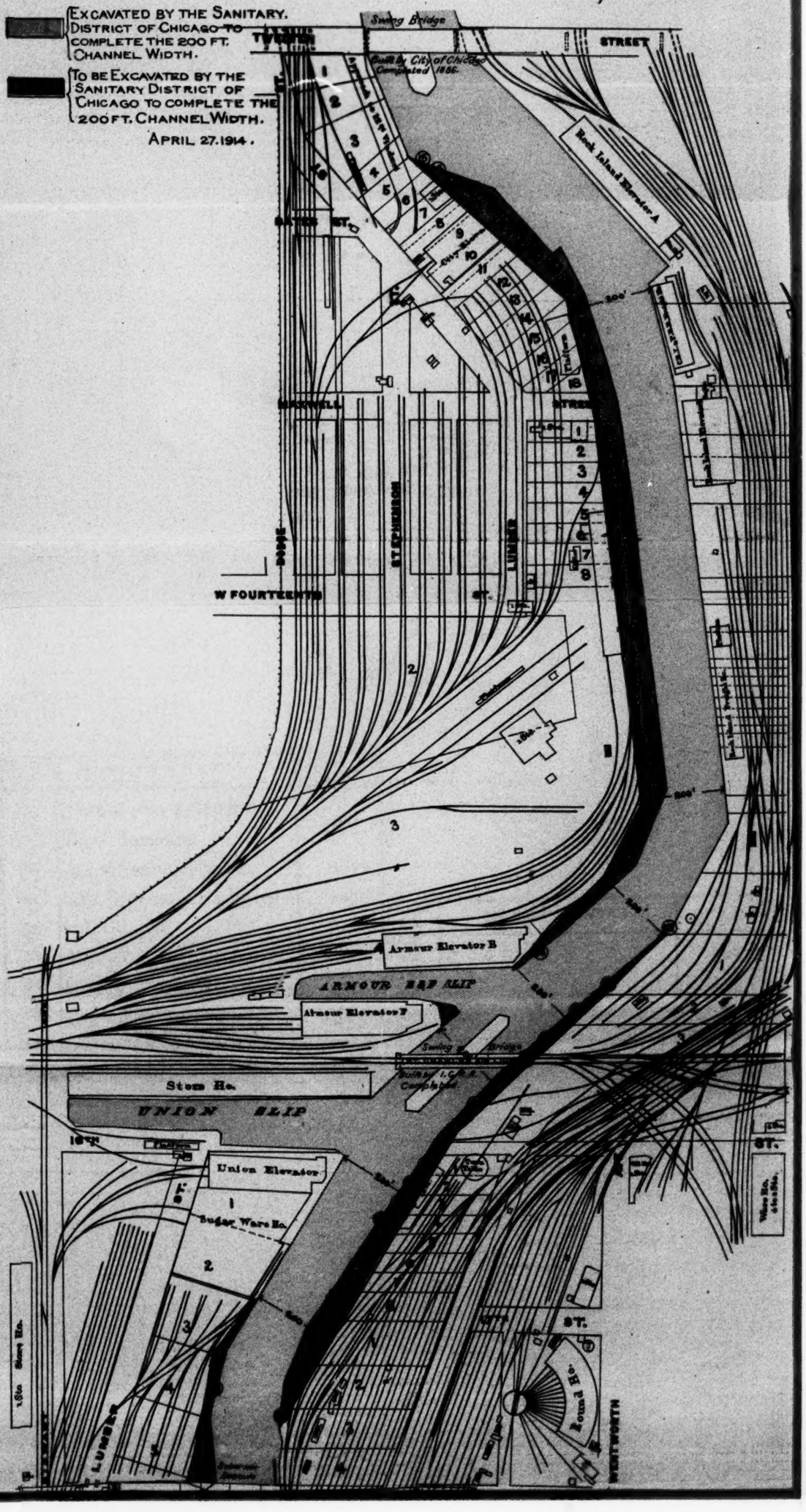
May 20 1914

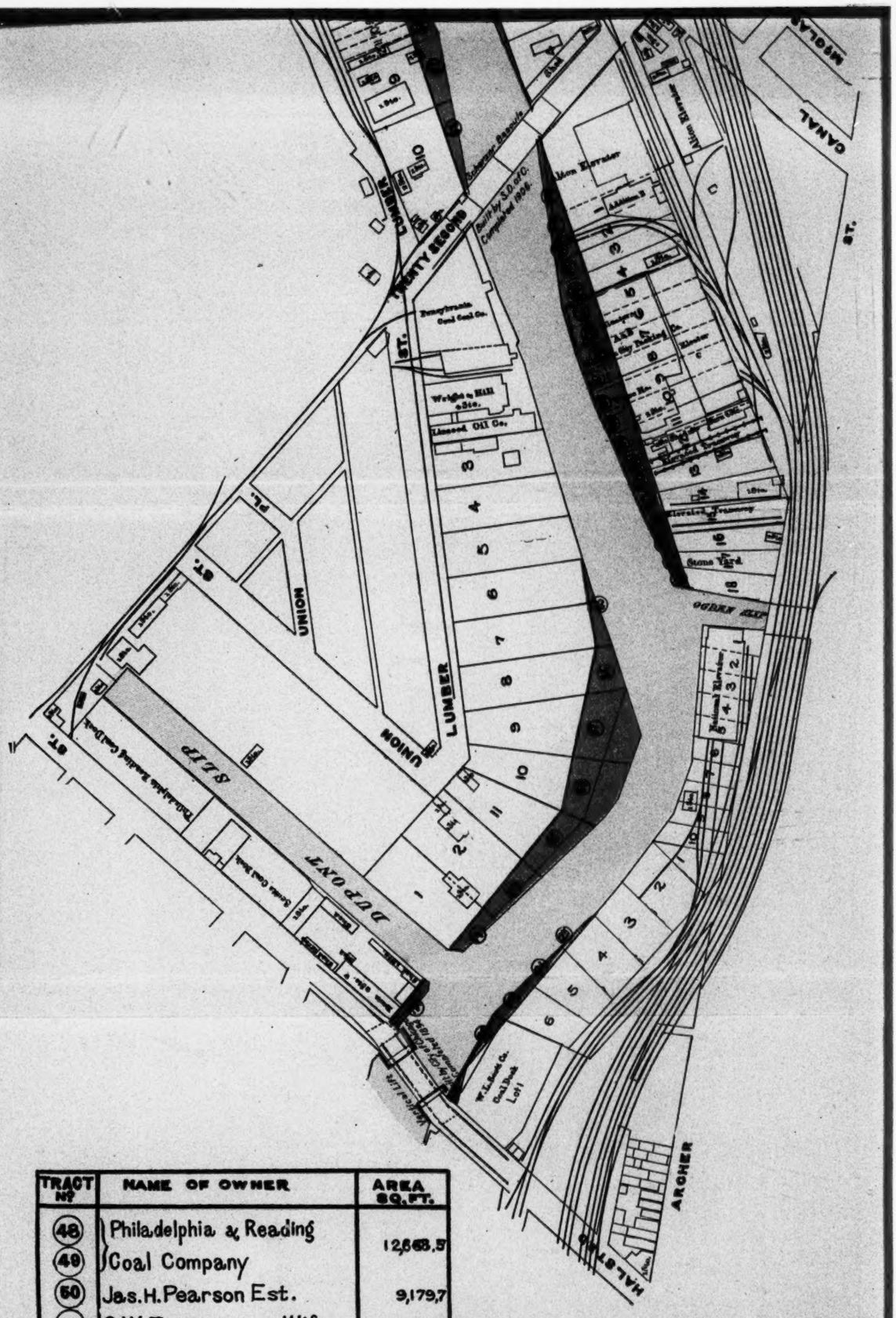
ORIGINAL WIDTH OF CHANNEL

EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH.

TO BE EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH.

APRIL 27. 1914.





TRACT Nº	NAME OF OWNER	AREA SQ. FT.
48	Philadelphia & Reading Coal Company	12,563.5
49		
50	Jas. H. Pearson Est.	9,179,7
51	C.W. Tegtmeyer & Wife	5406,0
52	H.D. Gibson	2,148,5
53	Mary C. Lilly & Husband	2,905,0
54	E. A. Lord et. al.	5,176,0
55		
56	Clarence E. Carr et. al.	6,839.0
57	W. Sherriffs	7,397.0
58	Illinois Stone Co.	4,480.0
65	B.F. Mc Connell	3,508.72
66	Mrs A. Babcock & Husband	25,570,02
67		
68		
69	Henry A. Du Pont	18,188,23
70		
71		
71A		
122	W.L. Scott & Co.	10,228,13
123		
124		

TRACT Nº	NAME OF OWNER	AREA SQ. FT.
125	C. & A. R.R. Co.	729,20
127 to 133 Incl.	Wm. B. Ogden Est. Western Stone Co.	15,593,47
134 to 140 Incl.	Nebraska City Packing Co.	27,595,80
141 to 145 Incl.	Seaverns Elevator Co.	14,836,19
149	Cosmopolitan Elec. Co.	1,912,65
150	General Chemical Co	816.41
41	Delaware Lackawanna R.R. et al	17,041.00
42		
41A	Robt. W. Hall & Wife	534.93
43	Thos. H. Hoyne et al.	7,631.03
44		
45	Jose B. King et. al.	23,133,92
46		
47		
146	Louis Hutt & Wife	7,101.9
147	Wm. R. Mamine & Wife	5,554.8
147A		

779

Wisner's Exhibit 10.

SANITARY DISTRICT OF CHICAGO

MAP

Showing

CHICAGO RIVER IMPROVEMENT

From

18TH STREET TO HALSTED STREET

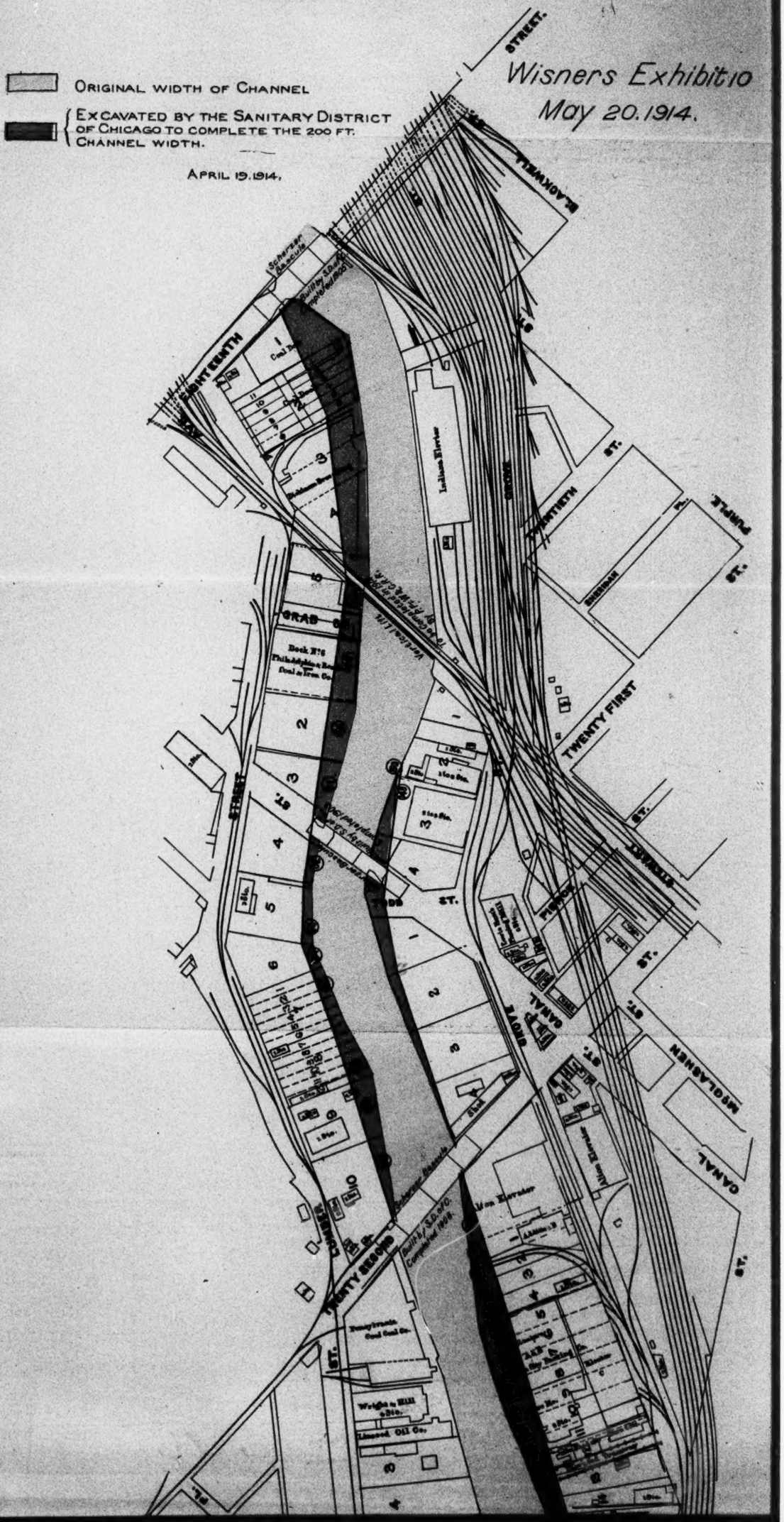
Scale 200Ft = 1Inch

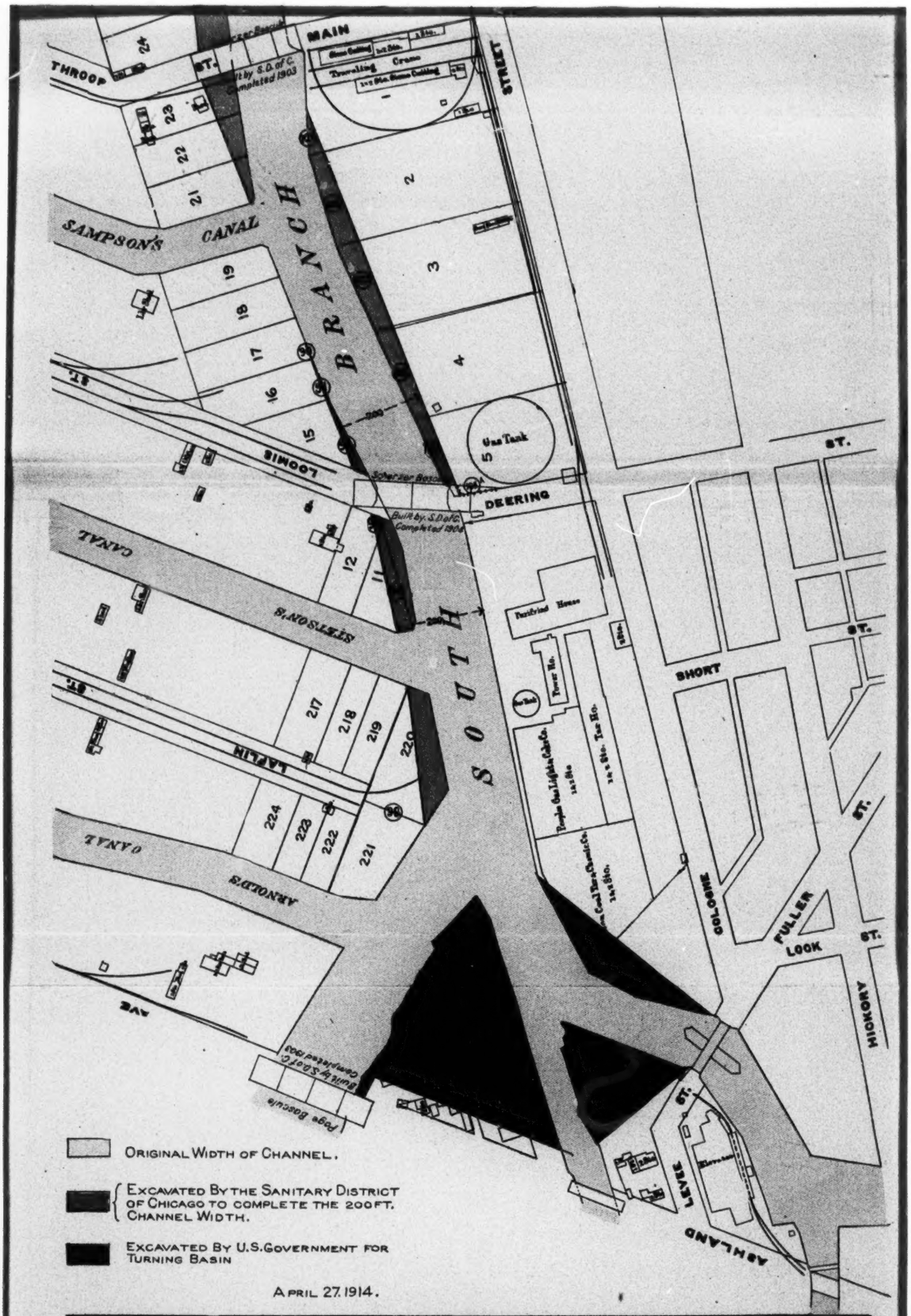
Wisners Exhibit 10
May 20. 1914.

ORIGINAL WIDTH OF CHANNEL

EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH.

APRIL 19. 1914.





ORIGINAL WIDTH OF CHANNEL.

EXCAVATED BY THE SANITARY DISTRICT OF CHICAGO TO COMPLETE THE 200 FT. CHANNEL WIDTH.

EXCAVATED BY U.S. GOVERNMENT FOR TURNING BASIN

APRIL 27. 1914.

TRACT Nº	NAME OF OWNER	AREA SQ. FT.
72		1,393,47
73	Omaha Packing Company	5,348,87
74	C. B & Q. R.R.	3,207,33
75		
76 to 82 inc	Commonwealth Electric Co.	20,927.85
90	L.W. Fargo	529,44
91		
92	Wm G. Roelker	1,404,80
93		
94		
96	Maxwell Bro's.	2 Lots 63,953,50
83 to 86 incl	The Peoples Gas Light & Coke Co.	4,529,00
87 to 89 incl	Henrietta A Boel & Husband	8 674.20

TRACT Nº	NAME OF OWNER	AREA SQ. FT.
105	Peoples Gas Light & Coke Co.	4,372,30
106	J.J. Mitchell et al	8,531,66
107	Francis B. Peabody Delia S. Gallup	11,255,55
108	Eliz Boyer	10,015,27
109	E. Heldmaier & Wife	
111	Estate of Benj. S. Rotch	9,580,66
112 & 112½	Commonwealth Electric Co.	5,065,70
113	Drexel Estate	1,173,42
114	North Western University	6,741.62
115	The Peoples Gas Light & Coke Co	10,422.77
116	Peoples Gas Light & Coke Co	312,97
118 to 121 inc	Estate of Edson Keith	11,598,96
110	Peoples Gas Light & Coke Co	5,110,00
105A	Peoples Gas Light & Coke Co	1,431,00

781

Wisner's Exhibit 11.

SANITARY DISTRICT OF CHICAGO

MAP

Showing

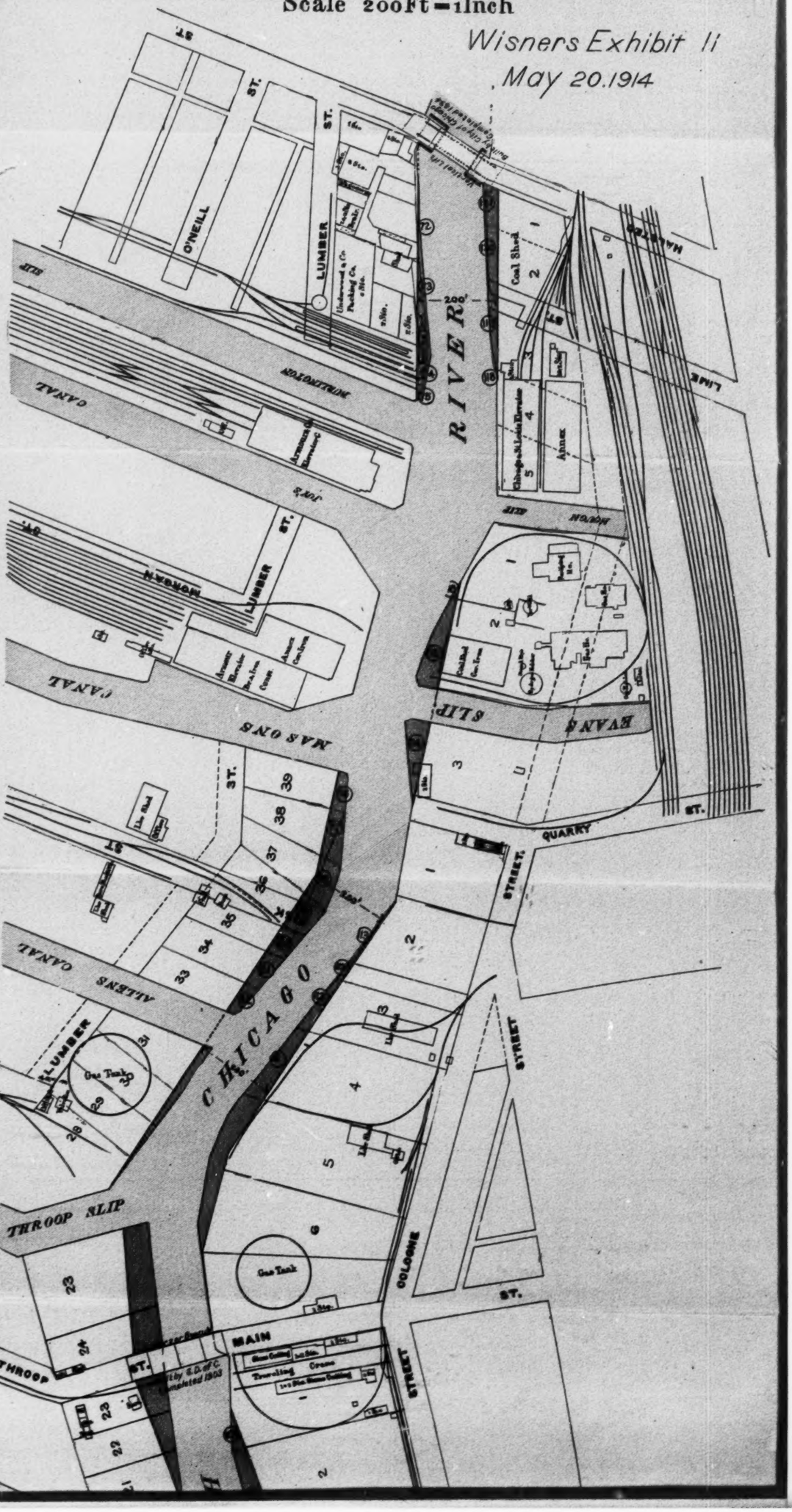
CHICAGO RIVER IMPROVEMENT

From

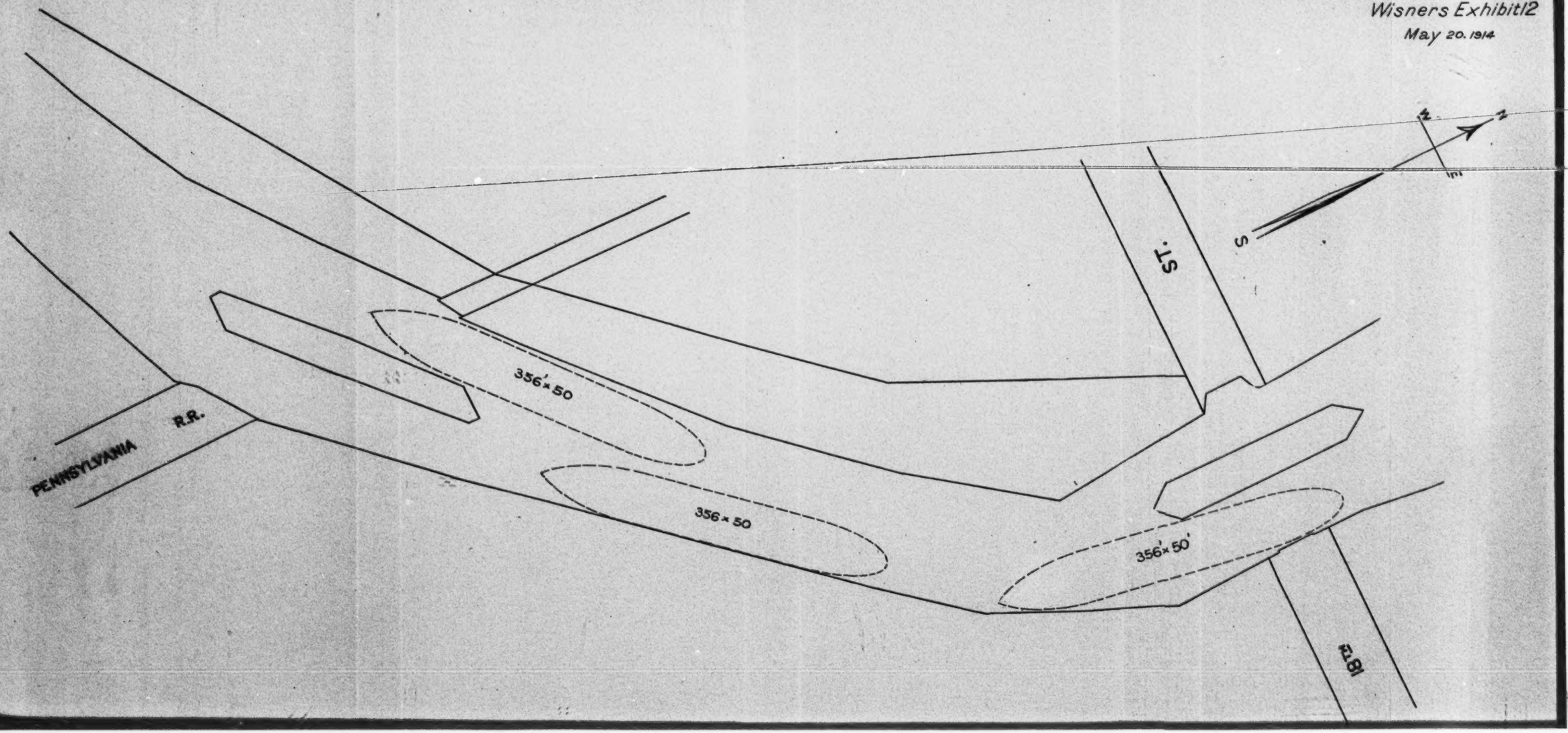
HALSTED STREET TO ASHLAND AVE

Scale 200Ft = 1Inch

Wisners Exhibit 11
May 20.1914



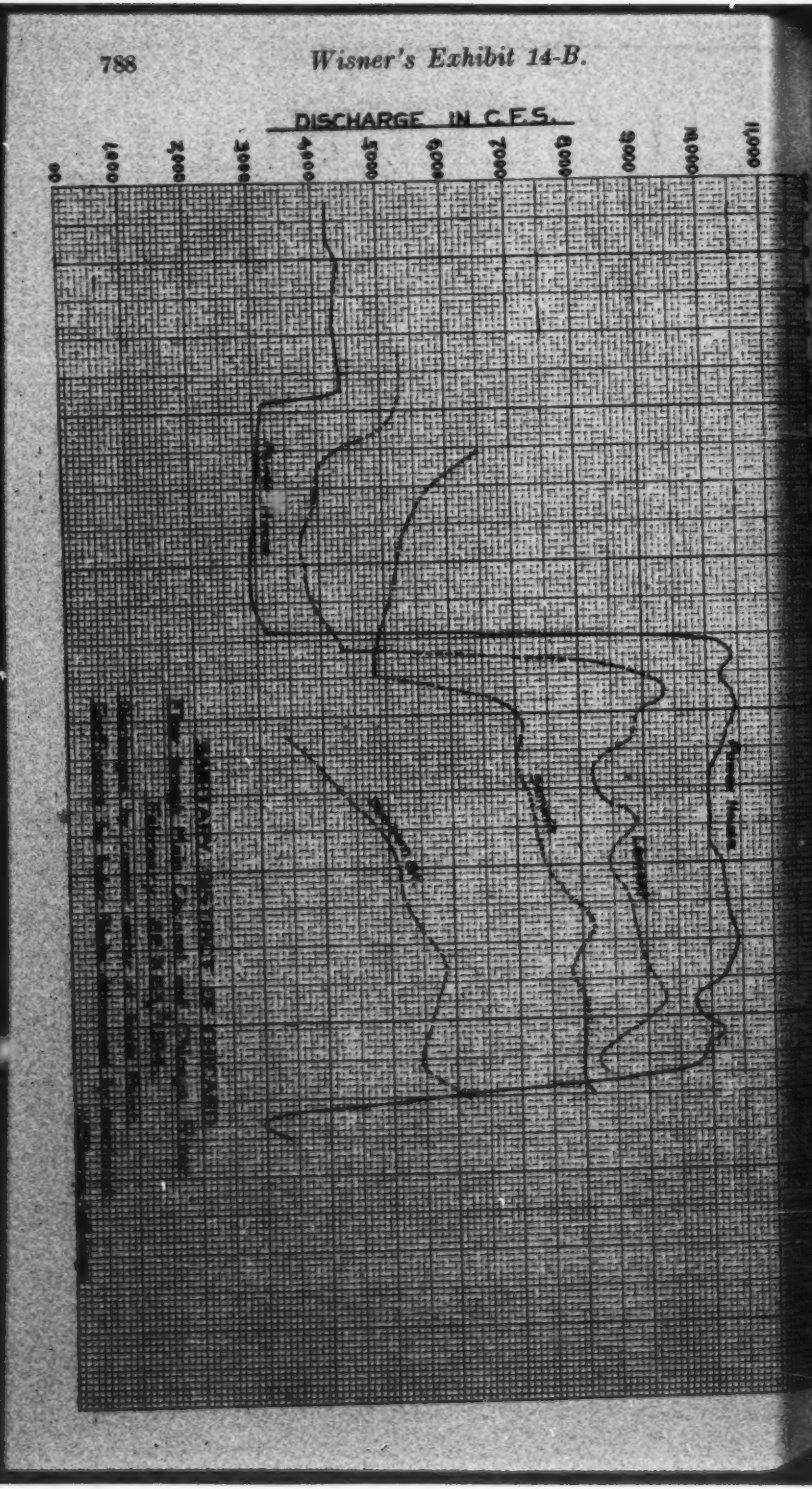
Wisners Exhibit12
May 20. 1914



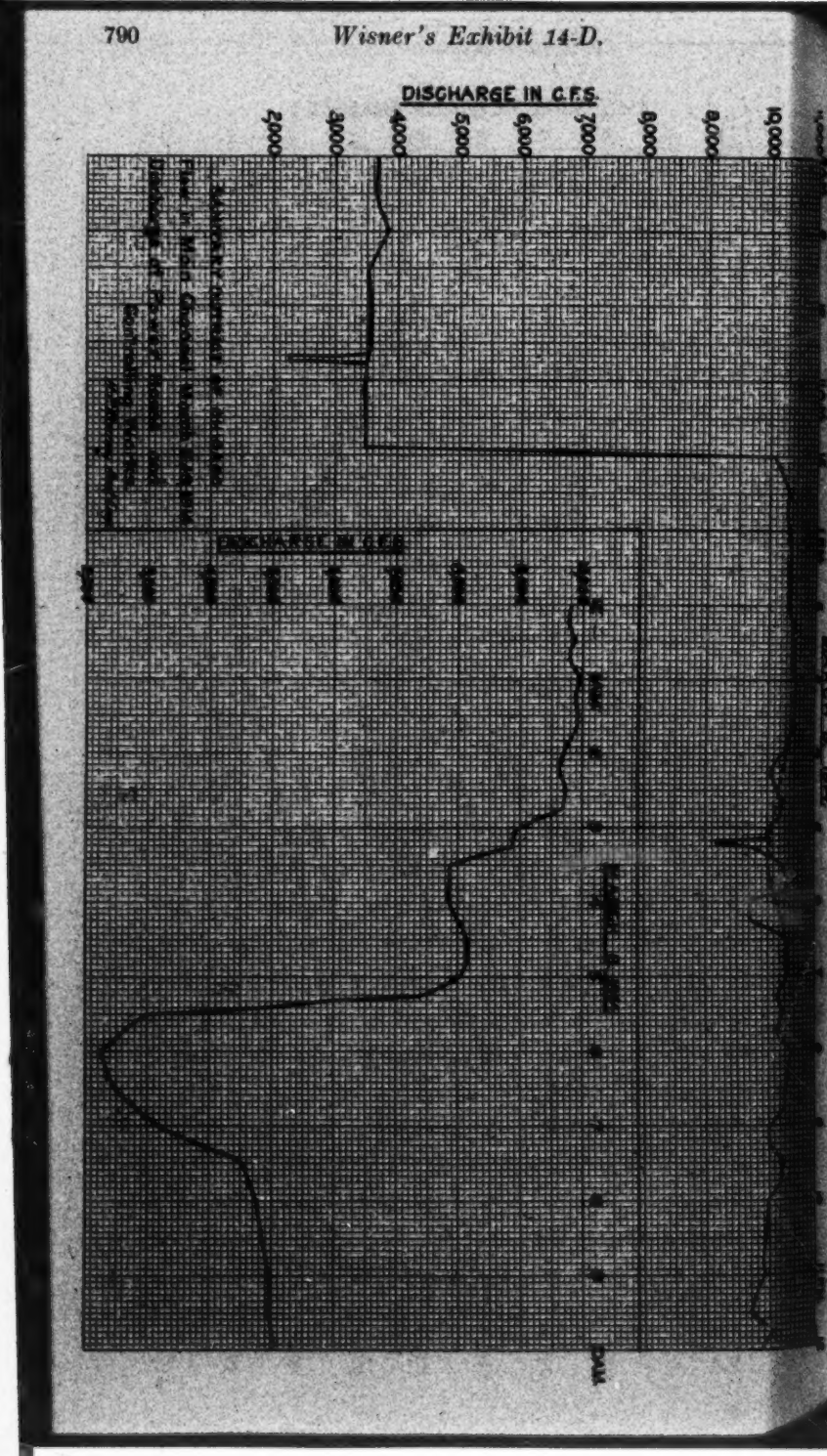
Wisners Exhibit 13
May 20. 1914

DISCHARGE IN C.F.S.
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
JPM
4
5
6
7
8
9
10
11PM
12
1AM
2
3
4
5
6
7AM
FEBRUARY 23, 1914
FEBRUARY 24, 1914

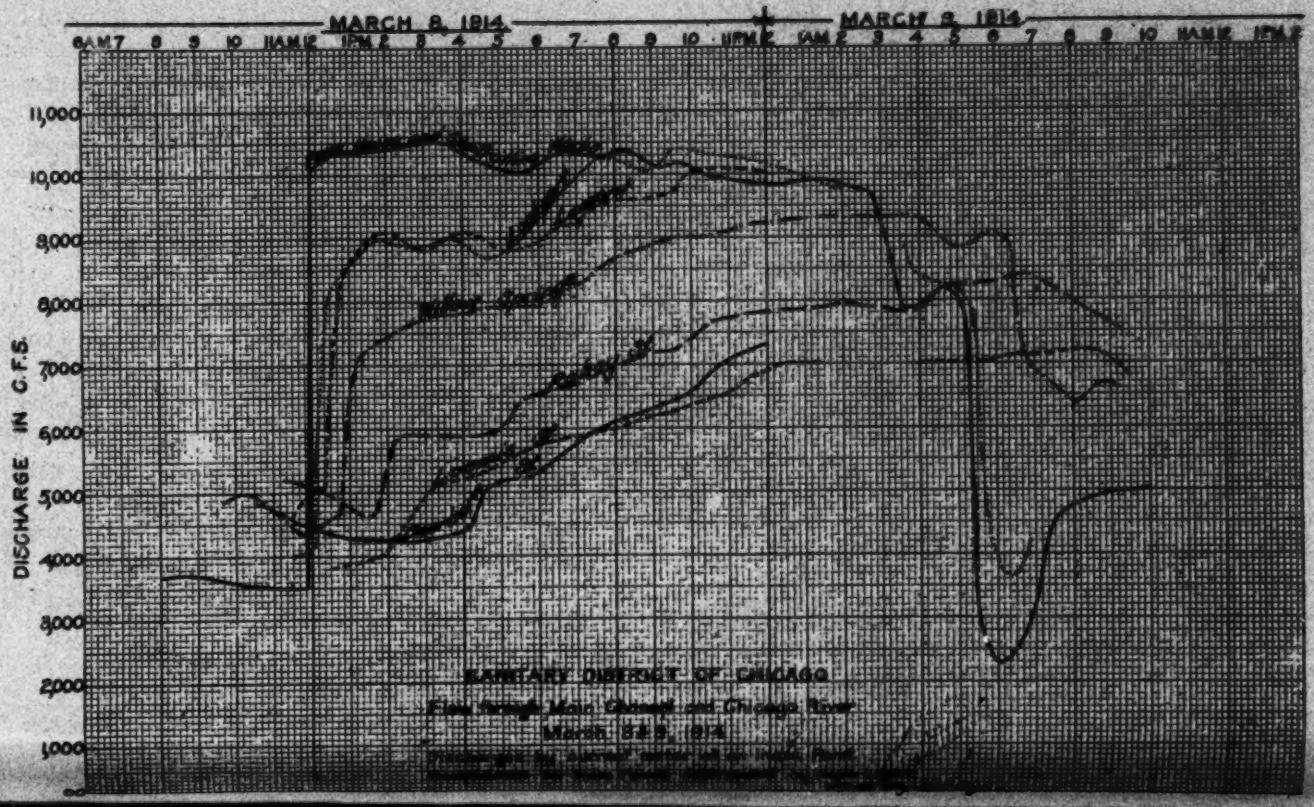
Wisner's Exhibit 14-B.

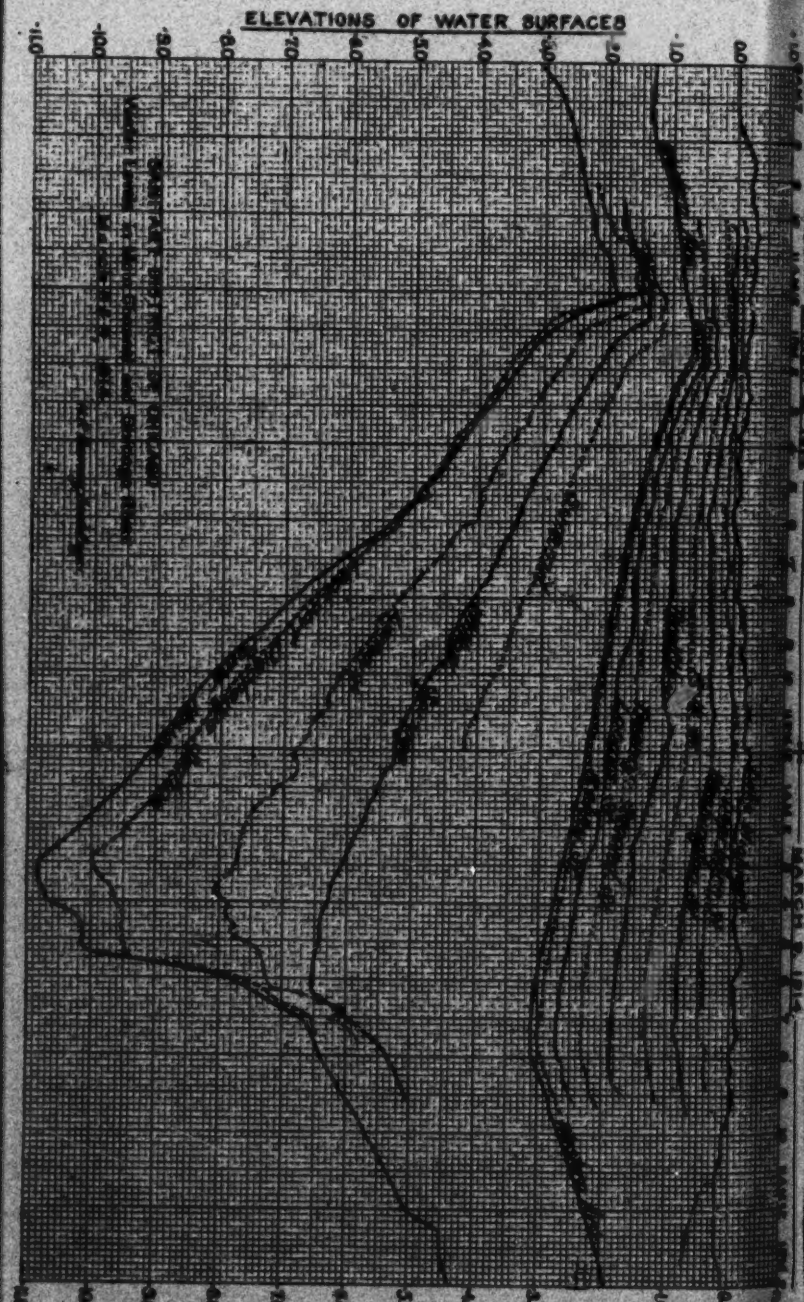


ELEVATIONS OF WATER SURFACES.
FEBRUARY 22, 1914
FEBRUARY 23, 1914


DISCHARGE IN C.F.S.
2000
3000
4000
5000
6000
7000
8000
9000
10,000
DISCHARGE IN C.F.S.

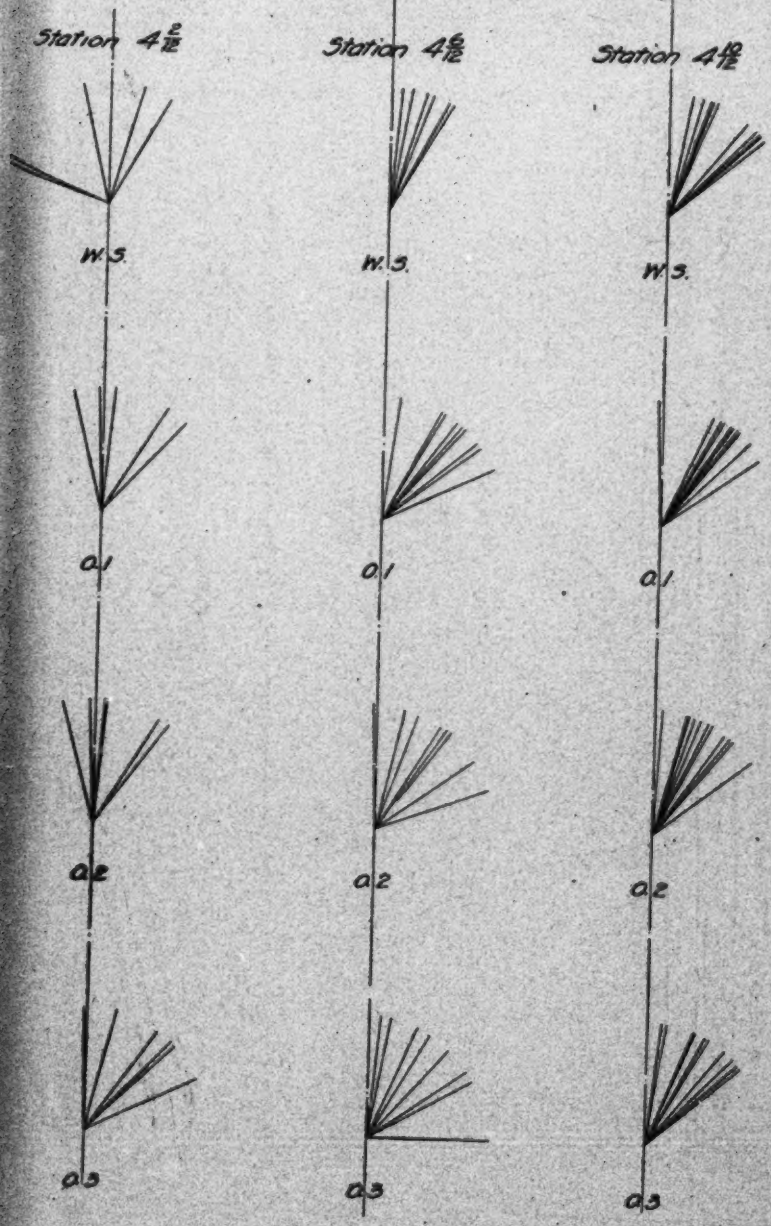
Wisner's Exhibit 14-E.




ELEVATIONS OF WATER SURFACES

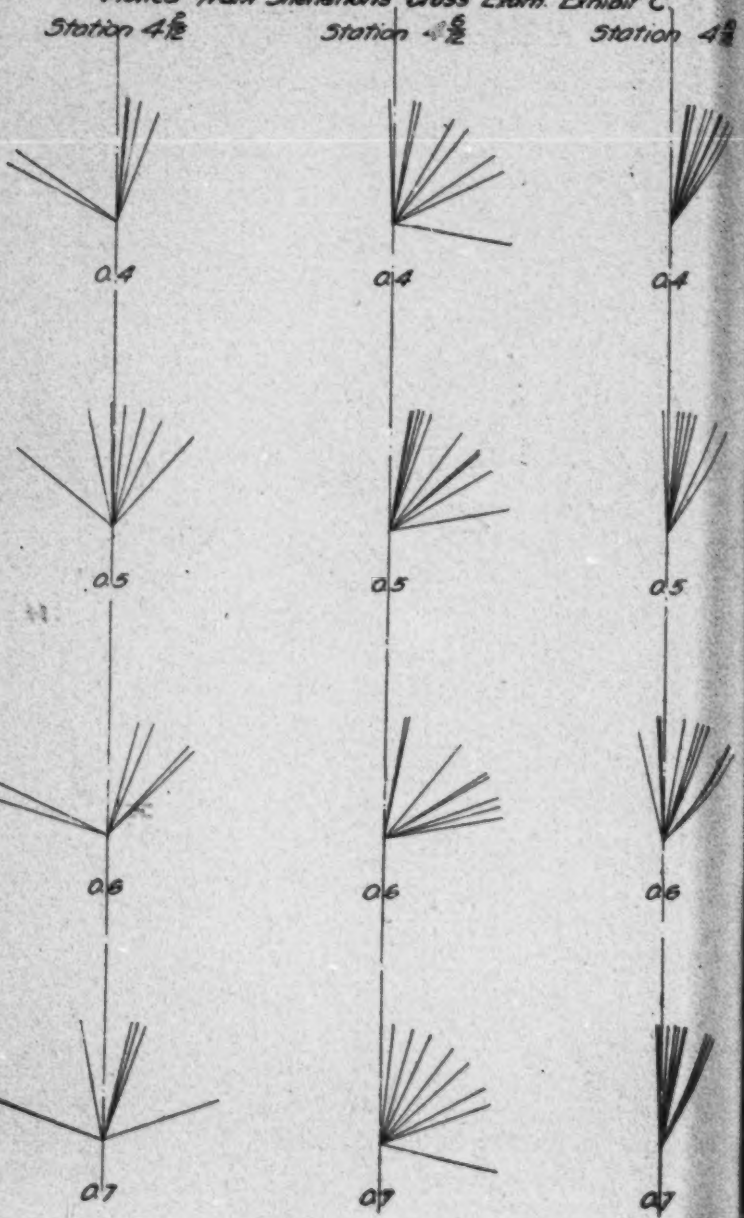
Williams Ex. 36 A

Direction Measurements of Vertical Curves
International Bridge
Plotted from Shenehon's Cross Exam. Exhibit C



Williams Ex. B

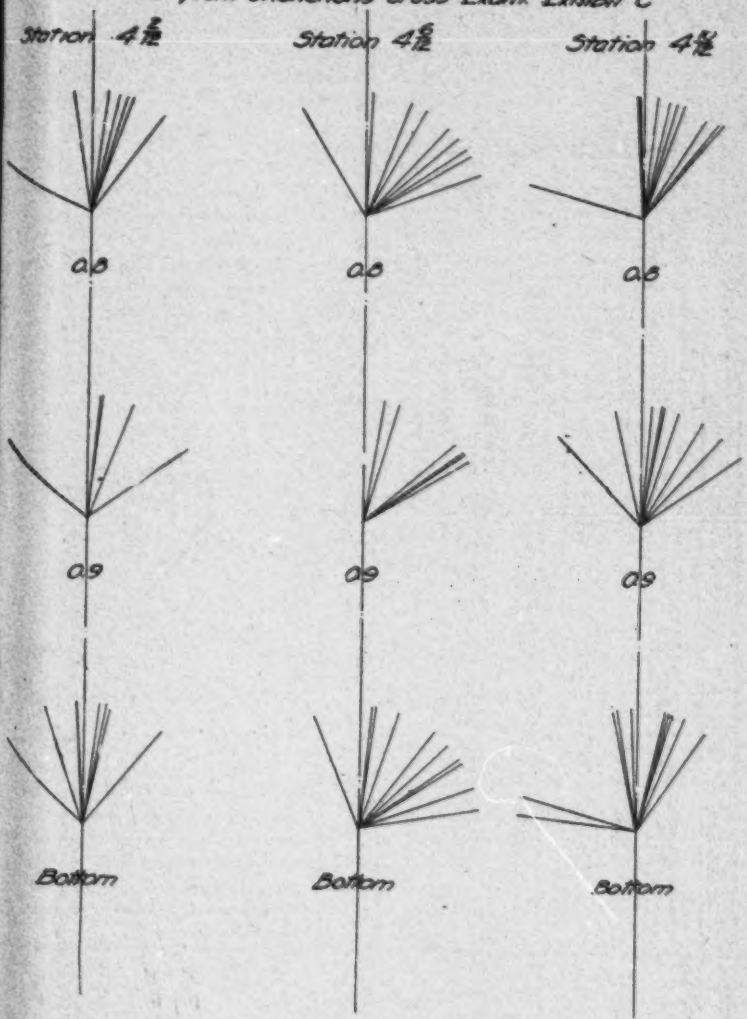
Direction Measurements of Vertical Curves
International Bridge
Plotted from Shanahan's Cross Exam. Exhibit C



Williams Ex. 36 C

Direction Measurements of Vertical Curves of International Bridge

Plotted from Shenehon's Cross Exam. Exhibit C



Williams Ex 37

LAKE LEVELS – NIAGARA RIVER

VERTICAL CURVES

SPAN 6 STATION 4/12 P.C. Sheeler

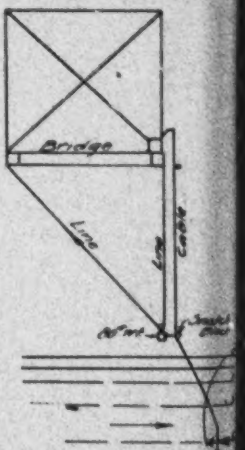
INTERNATIONAL BRIDGE SECTION Asst. Eng.

Date of Observation 1910	Number of Observation	Number of Verticals in Section	Velocity Surface Feet per Second: By 10.48 at No. Depths 3.465	By 6.328 at Three Depths 3.465	Percent Velocity at Surface to Velocity at 0.2 Depth (Large Section) m g	Weight of Obs (Proportional to Time Run)	Weighted Mean Percentages h
a	b	c	d	e	f	g	h
Feb 2	1	10	4.46	3.70	83.6	5	
" 6	1	10	3.71	3.20	91.0	5	
" 6	1	5	4.04	3.33	90.3	1	
" 6	1	5	3.88	3.31	93.7	1	
" 6	1	6	4.82	3.42	91.3	1	90.8
Feb 2	2	10	4.30	3.87	90.3	5	
" 6	2	10	3.87	3.26	90.1	5	
" 6	2	5	3.88	3.38	91.0	1	
" 6	2	5	4.24	3.50	90.0	1	
" 6	2	6	4.17	3.38	88.7	1	83.1
Feb 2	3	10	4.38	3.86	91.7	5	
" 6	3	10	3.82	3.33	90.1	5	
" 6	3	5	3.79	3.40	92.1	1	
" 6	3	5	4.13	3.51	88.9	1	
" 6	3	6	4.06	3.43	92.7	1	90.6
Feb 2	4	10	4.43	3.80	88.8	5	
" 6	4	10	3.86	3.36	91.1	5	
" 6	4	5	3.87	3.38	93.1	1	
" 6	4	5	4.16	3.47	88.6	1	
" 6	4	6	3.97	3.39	96.3	1	90.8
Feb 6	5	10	3.71	3.17	90.8	5	
" 6	5	5	3.63	3.20	94.0	1	
" 6	5	5	4.03	3.38	92.7	1	
" 6	5	6	4.06	3.48	92.2	1	91.4
Feb 6	6	10	3.96	3.40	94.7	6	
" 6	6	5	3.80	3.26	91.2	1	
" 6	6	5	3.83	3.31	97.7	1	
" 6	6	6	4.06	3.43	93.3	1	83.6
Feb 6	7	10	3.82	3.44	90.1	5	
" 6	7	5	3.83	3.30	91.6	1	
" 6	7	5	4.01	3.43	77.0	1	
" 6	7	6	3.83	3.31	96.0	1	89.6
Feb 6	8	10	3.91	3.36	70.4	5	
" 6	8	5	3.78	3.29	68.7	1	
" 6	8	5	4.00	3.38	68.7	1	
" 6	8	6	3.98	3.35	64.5	1	68.5
Feb 6	9	10	3.80	3.26	71.7	5	
" 6	9	5	3.96	3.43	67.6	1	
" 6	9	5	3.70	3.23	76.7	1	
" 6	9	6	3.92	3.36	78.5	1	
" 6	9	6	3.98	3.40	70.1	1	
" 6	9	6	4.03	3.39	77.0	1	71.2

Water Surface 567.2 0.00

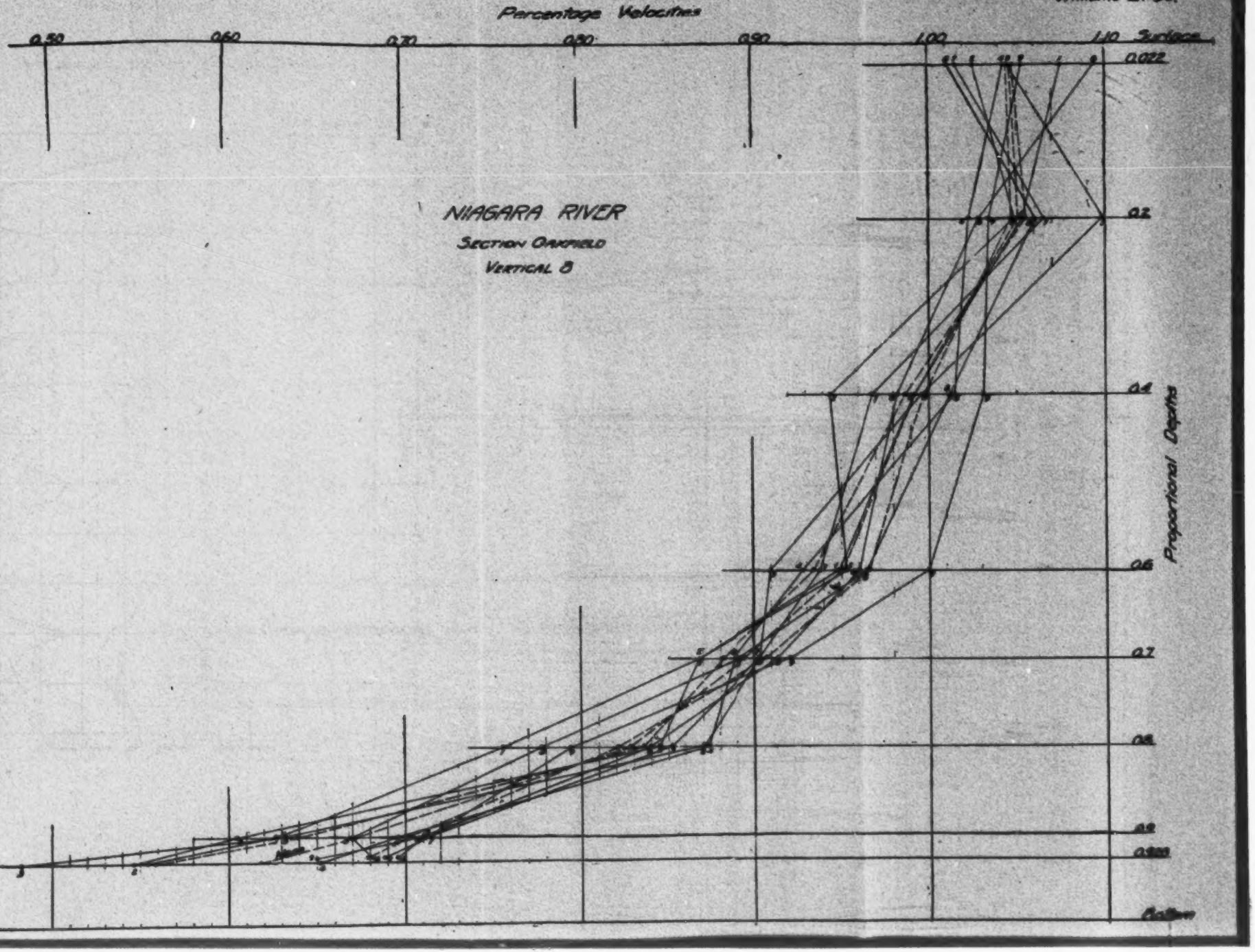
Weighted mean velocity in discharge 3.46 6.00

To obtain velocity in units corresponding to Percentages multiply h by 6.00

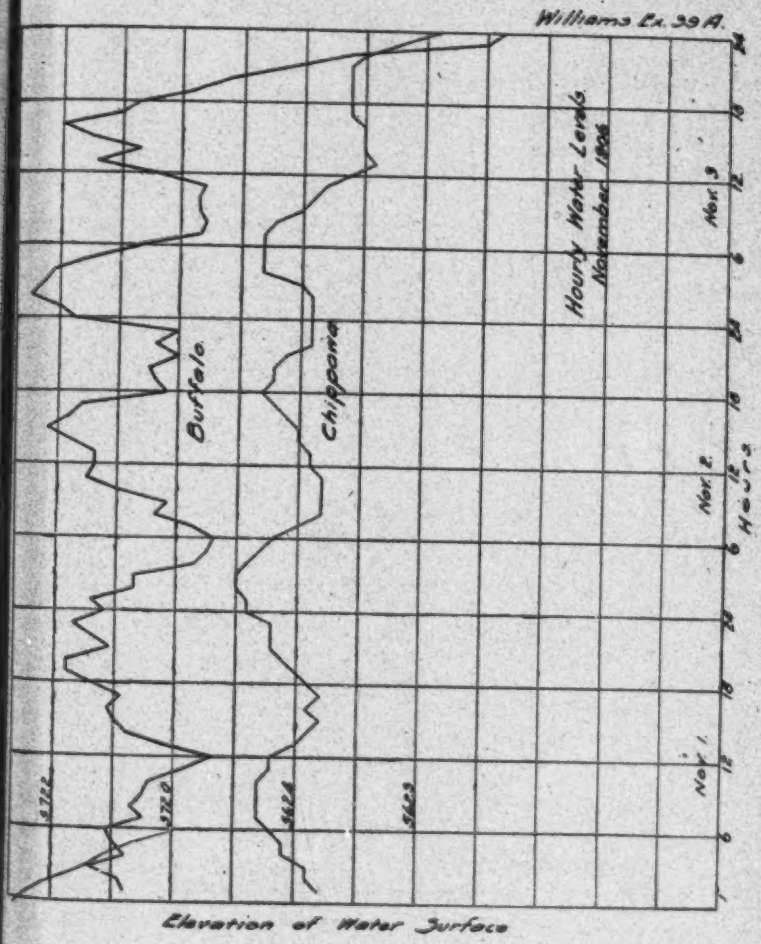


Meter was allowed to go downstream without guys at 1/4, 6 and 9/10 depths. At each depths was made to descend in a vertical line (in both planes) through its position at 8/10 Cable & sinker was used, no sinker with Cable assumed straight line below Snatch block.

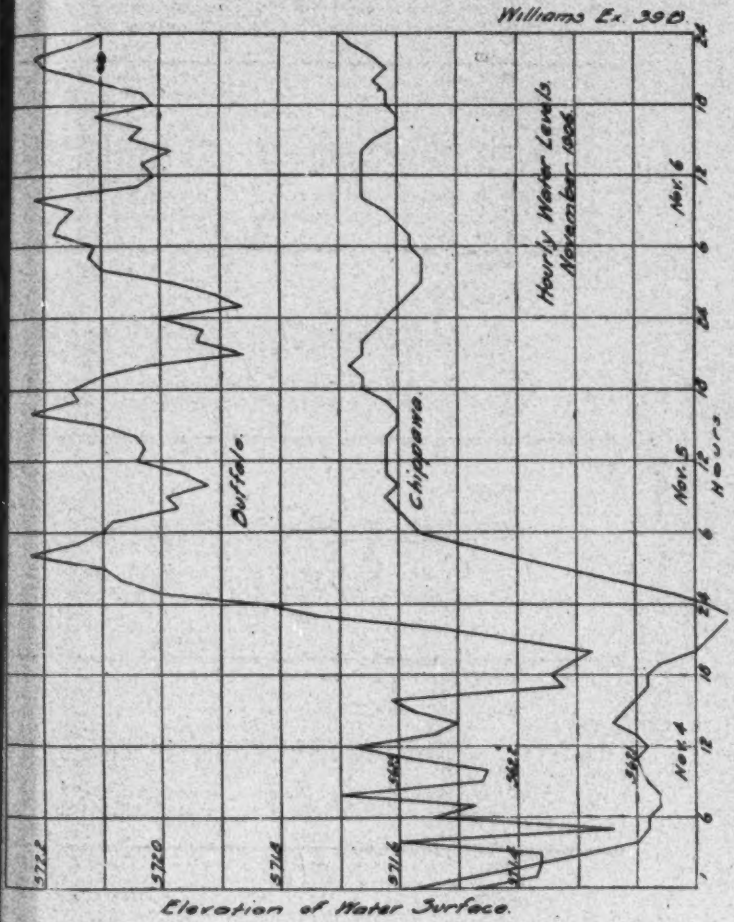
Williams Ex. 38.



(Being Shenehon's Exhibit A on Cross Examination)



(Being Shenehon's Exhibit B on Cross Examination)



WILLIAMS EXHIBIT 39-C.

(Being Shenehon's Exhibit C on Cross Examination.)

Harvey H. Atwell
Feb. 21, 1899

DIRECTION MEASUREMENTS OF VERTICAL CURVES AT INTERNATIONAL BRIDGE, BUFFALO, N. Y., 1897.

Span 3

Station 3⅛				Station 3⅝			
Depth	Register	Book	Page	Depth	Register	Book	Page
Bottom	215°	4	1	Bottom	184°	4	11
0.9	193°	"	"	0.9	184°	"	"
0.6	190°	"	"	0.8	184°	"	"
0.5	213°	"	"	0.7	185°	"	"
0.4	188°	"	"	0.6	187°	"	"
0.3	184°	"	"	0.5	185°	"	"
				0.4	184°	"	"
0.9	176°	4	10	0.3	186°	"	"
0.8	181°	"	10	0.2	184°	"	"
				0.1	185°	"	"
Bottom	184	4	10	Surface	180°	"	"
0.9	183	"	"				
0.8	185	"	"	Bottom	184°	4	12
0.7	182	"	"	0.9	185°	"	"
0.6	187	"	"	0.8	178°	"	"
0.5	184	"	"	0.7	178°	"	"
0.4	184	"	"	0.6			
0.3	185	"	"	0.5	185°	"	"
0.2	184	"	"	0.4	184°	"	"
0.1	184	"	"	0.3	184°	"	"
Surface	182	"	"	0.2	184°	"	"
				0.1	183°	"	"
Bottom	181°	4	11	Surface	183°	"	"
0.9	183°	"	"				

Span 4

Station 4$\frac{5}{16}$				Station 4$\frac{7}{16}$			
Depth	Register	Book	Page	Depth	Register	Book	Page
Bottom	176°	4	32	Bottom	199°	4	30
0.9	180°	"	"	0.9	197°	"	"
0.8	170°	"	"	0.8	230°	"	"
0.7	168°	"	"	0.7	282°	"	"
0.6	195°	"	"	0.6	260°	"	"
0.5	185°	"	"	0.5	191°	"	"
0.4	184°	"	"	0.4	178°	"	"
0.3	178°	"	"	0.3	270°	"	"
0.2	177°	"	"	0.2	250°	"	"
0.1	178°	"	"	0.1	222°	"	"
Surface	180°	"	"	Surface	200°	"	"
Bottom	132°	4	43	Bottom	260°	4	30
0.9	128°	"	"	0.9	240°	"	"
0.8	114°	"	"	0.8	183°	"	"
0.7	109°	"	"	0.7	205°	"	"
0.6	226°	"	"	0.6	255°	"	"
0.5	167°	"	"	0.5	260°	"	"
0.4	116°	"	"	0.4	245°	"	"
0.3	225°	"	"	0.3	240°	"	"
0.2	185°	"	"	0.2	178°	"	"
0.1	166°	"	"	0.1	220°	"	"
Surface	112°	"	"	Surface	210°	"	"

Station 4$\frac{9}{16}$				Station 4$\frac{11}{16}$			
Depth	Register	Book	Page	Depth	Register	Book	Page
Bottom	220°	5	47	Bottom	187°	5	44
0.9	202°	"	"	0.9	197°	"	"
0.8	200°	"	"	0.8	210°	"	"
0.7	193°	"	"	0.7	187°	"	"
0.6	223°	"	"	0.6	220°	"	"
0.5	222°	"	"	0.5	196°	"	"
0.4	202°	"	"	0.4	219°	"	"
0.3	223°	"	"	0.3	190°	"	"
0.2	212°	"	"	0.2	212°	"	"
0.1	212°	"	"	0.1	188°	"	"
Surface	196°	"	"	Surface	190°	"	"
Bottom	187°	5	48	Bottom	157°	5	45
0.9	235°	"	"	0.9	236°	"	"
0.8	217°	"	"	0.8	224°	"	"
0.7	200°	"	"	0.7	227°	"	"
0.6	195°	"	"	0.6	251°	"	"
0.5	205°	"	"	0.5	240°	"	"
				0.4	236°	"	"
				0.3	235°	"	"
				0.2	194°	"	"
				0.1	217°	"	"
				Surface	200°	"	"

Station 4$\frac{13}{16}$			
Depth	Register	Book	Page
Bottom	218	5	41
0.9	230	"	"
0.8	236	"	"

Span 3	0.8	184°	"	"
	0.7	183°	"	"
	0.6	183°	"	"
	0.5	186°	"	"
	0.4	178°	"	"
	0.3	183°	"	"
	0.2	181°	"	"
	0.1	182°	"	"
	Surface	184°	"	"
	Bottom	220°	5	58
	0.9	220°	"	"
	0.8	123°	"	"
	0.7	172°	"	"
	0.6	221°	"	"
	0.5	211°	"	"
	0.4	173°	"	"
	0.3	200°	"	"
	0.2	202°	"	"
	0.1	218°	"	"
	Surface	225°	"	"
	Bottom	179°	5	59
	0.9	190°	"	"
	0.8	187°	"	"
	0.7	178°	"	"
	0.6	177°	"	"
	0.5	218°	"	"
	0.4	200°	"	"
	0.3	199°	"	"
	0.2	216°	"	"
	0.1	227°	"	"
	Surface	212°	"	"
Span 4	Bottom	161°	4	43
	0.9	127°	"	"
	0.8	187°	"	"
	0.7	110°	"	"
	0.6	114°	"	"
	0.5	128°	"	"
	0.4	185°	"	"
	0.3	193°	"	"
	0.2	184°	"	"
	0.1	166°	"	"
	Surface	109°	"	"
	Bottom	190°	4	43
	0.9	185°	"	"
	0.8	197°	"	"
	0.7	250°	"	"
	0.6	106°	"	"
	0.5	179°	"	"
	0.4	191°	"	"
	0.3	244°	"	"
	0.2	164°	"	"
	0.1	223°	"	"
	Surface	167°	"	"
	Bottom	235°	4	31
	0.9	235°	"	"
	0.8	240°	"	"
	0.7	250°	"	"
	0.6	260°	"	"
	0.5	200°	"	"
	0.4	280°	"	"
	0.3	210°	"	"
	0.2	200°	"	"
	0.1	245°	"	"
	Surface	190°	"	"
	Bottom	260°	4	31
	0.9	230°	"	"
	0.8	250°	"	"
	0.7	250°	"	"
	0.6	190°	"	"
	0.5	230°	"	"
	0.4	178°	"	"
	0.3	235°	"	"
	0.2	235°	"	"
	0.1	230°	"	"
	Surface	210°	"	"
	0.7	241	"	"
	0.6	192	"	"
	0.5	190	"	"
	0.4	190	"	"
	0.3	222	"	"
	0.2	215	"	"
	0.1	233	"	"
	Surface	197	"	"
	Bottom	237°	5	42
	0.9	236°	"	"
	0.8	202°	"	"
	0.7	241°	"	"
	0.6	238°	"	"
	0.5	229°	"	"
	0.3	203°	"	"
	Bottom	185°	5	43
	0.9	190°	"	"
	0.8	148°	"	"
	0.7	196°	"	"
	0.6	190°	"	"
	0.5	194°	"	"
	0.4	210°	"	"
	0.3	185°	"	"
	0.2	203°	"	"
	0.1	208°	"	"
	Surface	208°	"	"
	Bottom	226°	5	46
	0.9	235°	"	"
	0.8	230°	"	"
	0.7	217°	"	"
	0.6	240°	"	"
	0.5	217°	"	"
	0.4	192°	"	"
	0.3	190°	"	"
	0.2	217°	"	"
	0.1	210°	"	"
	Surface	185°	"	"
Station 4 $\frac{3}{10}$	Bottom	192°	4	42
	0.9	186°	"	"
	0.8	193°	"	"
	0.7	196°	"	"
	0.6	202°	"	"
	0.5	195°	"	"
	0.4	123°	"	"
	0.3	215°	"	"
	0.2	217°	"	"
	0.1	185°	"	"
	Surface	210°	"	"

WILLIAMS EXHIBIT 39-D.

(Being Shenehon's Exhibit D on Cross Examination.)

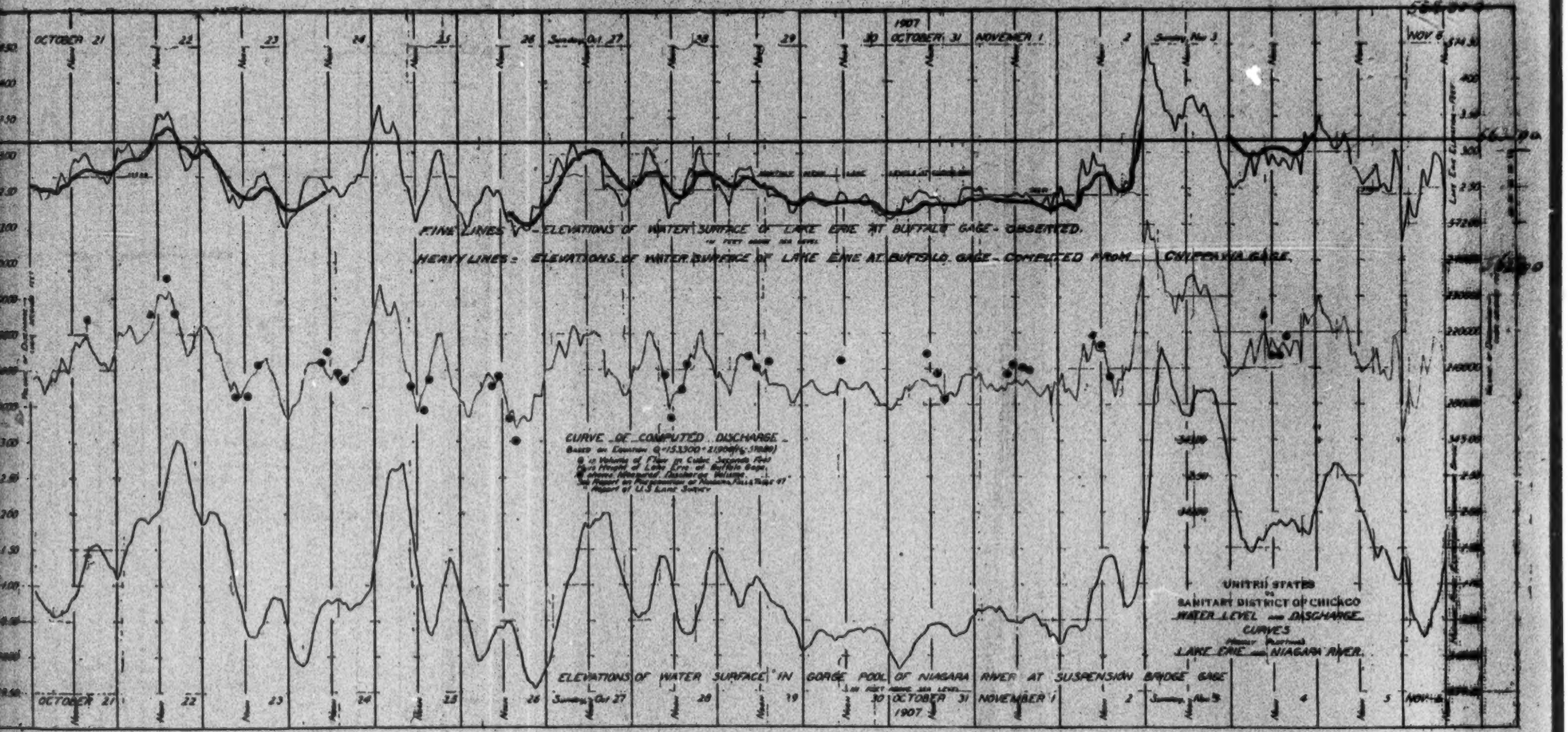
DIRECTION MEASUREMENTS OF VERTICAL CURVES AT INTERNATIONAL BRIDGE, BUFFALO, N. Y., 1897.

	Station 4 $\frac{19}{21}$				Station 4 $\frac{19}{21}$				Station 4 $\frac{19}{21}$					Station				Station				Station			
	Depth	Register	Book	Page	Depth	Register	Book	Page	Depth	Register	Book	Page		Depth	Register	Book	Page	Depth	Register	Book	Page	Depth	Register	Book	Page
Span 4	Bottom	177°	4	29	Bottom	97°	4	45	Bottom	168°	4	46	Span 5												
	0.9	166°	"	"	0.9	136°	"	"	0.9	198°	"	"													
	0.8	177°	"	"	0.8	187°	"	"	0.8	197°	"	"													
	0.7	177°	"	"	0.7	182°	"	"	0.7	190°	"	"													
	0.6	177°	"	"	0.6	221°	"	"	0.6	197°	"	"													
	0.5	185°	"	"	0.5	187°	"	"	0.5	193°	"	"													
	0.4	197°	"	"	0.4	191°	"	"	0.4	206°	"	"													
	0.3	219°	"	"	0.3	211°	"	"	0.3	203°	"	"													
	0.2	196°	"	"	0.2	208°	"	"	0.2	206°	"	"													
	0.1	210°	"	"	0.1	217°	"	"	0.1	215°	"	"													
	Surface	195°	"	"	Surface	231°	"	"	Surface	225°	"	"													
	Bottom	170°	4	29	Bottom	197°	4	45	Bottom	215°	5	39													
	0.9	235°	"	"	0.9	190°	"	"	0.9	223°	"	"													
	0.8	178°	"	"	0.8	212°	"	"	0.8	221°	"	"													
	0.7	178°	"	"	0.7	208°	"	"	0.7	206°	"	"													
	0.6	178°	"	"	0.6	166°	"	"	0.6	203°	"	"													
	0.5	178°	"	"	0.5	180°	"	"	0.5	190°	"	"													
	0.4	200°	"	"	0.4	205°	"	"	0.4	212°	"	"													
	0.3	225°	"	"	0.3	229°	"	"	0.3	189°	"	"													
	0.2	195°	"	"	0.2	199°	"	"	0.2	215°	"	"													
	0.1	205°	"	"	0.1	218°	"	"	0.1	214°	"	"													
	Surface	175°	"	"	Surface	227°	"	"	Surface	199°	"	"													

No. 3—Continued.

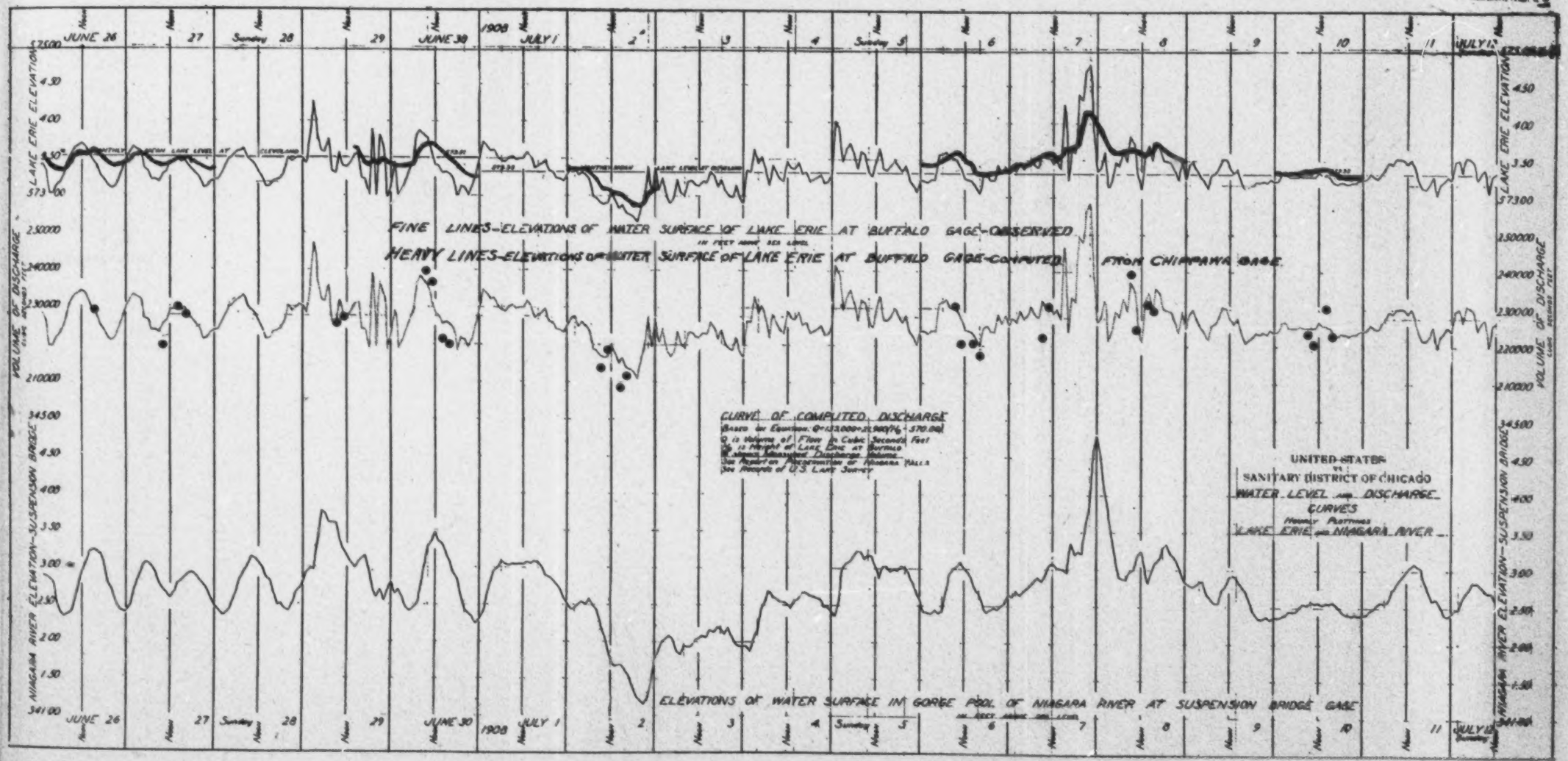
Span 4								Span 5							
Bottom	195°	4	30	Bottom		4	46	Bottom	193°	5	40				
0.9	185°	"	"	0.9	211°	"	"	0.9	191°	"	"				
0.8	200°	"	"	0.8	212°	"	"	0.8	219°	"	"				
0.7	186°	"	"	0.7	208°	"	"	0.7	191°	"	"				
0.6	190°	"	"	0.6	226°	"	"	0.6	226°	"	"				
0.5	190°	"	"	0.5	205°	"	"	0.5	213°	"	"				
0.4	205°	"	"	0.4	206°	"	"	0.4	189°	"	"				
0.3	187°	"	"	0.3	209°	"	"	0.3	231°	"	"				
0.2	184°	"	"	0.2	220°	"	"	0.2	233°	"	"				
0.1	178°	"	"	0.1	209°	"	"	0.1	235°	"	"				
Surface	190°	"	"	Surface	220°	"	"	Surface	200°						
Bottom	106°	4	44	Bottom	203°	4	46								
0.9	166°	"	"	0.9	166°	"	"								
0.8	106°	"	"	0.8	193°	"	"								
0.7	188°	"	"	0.7	203°	"	"								
0.6	220°	"	"	0.6	200°	"	"								
0.5	185°	"	"	0.5	187°	"	"								
0.4	188°	"	"	0.4	215°	"	"								
0.3	202°	"	"	0.3	229°	"	"								
0.2	202°	"	"	0.2	218°	"	"								
0.1	226°	"	"	0.1	215°	"	"								
Surface	202°	"	"	Surface	228°	"	"								

Williams Exhibit 89-E 1.
(Being Shonehon's Exhibit E 1 on Cross Examination.)

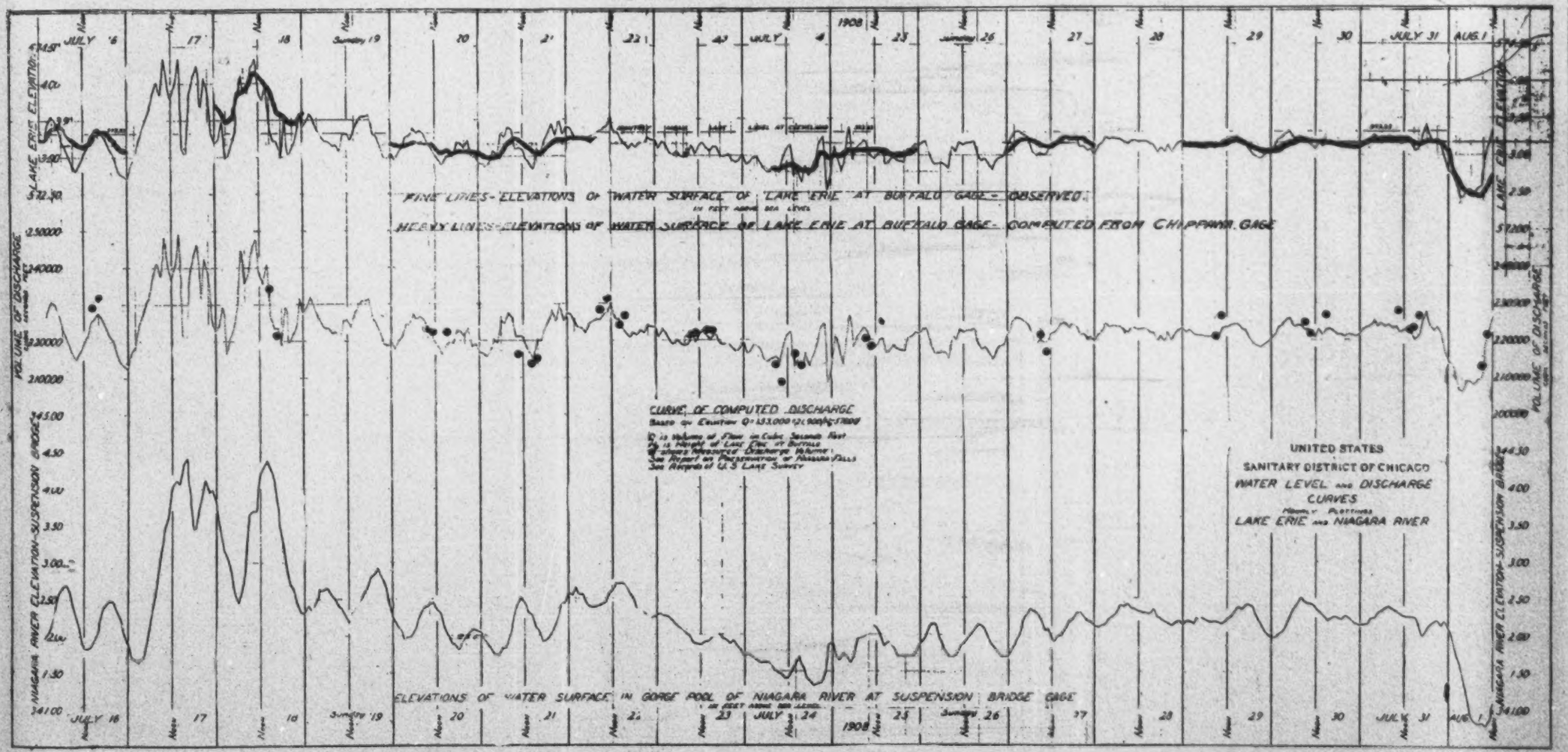


William's Exhibit 39-E 2.

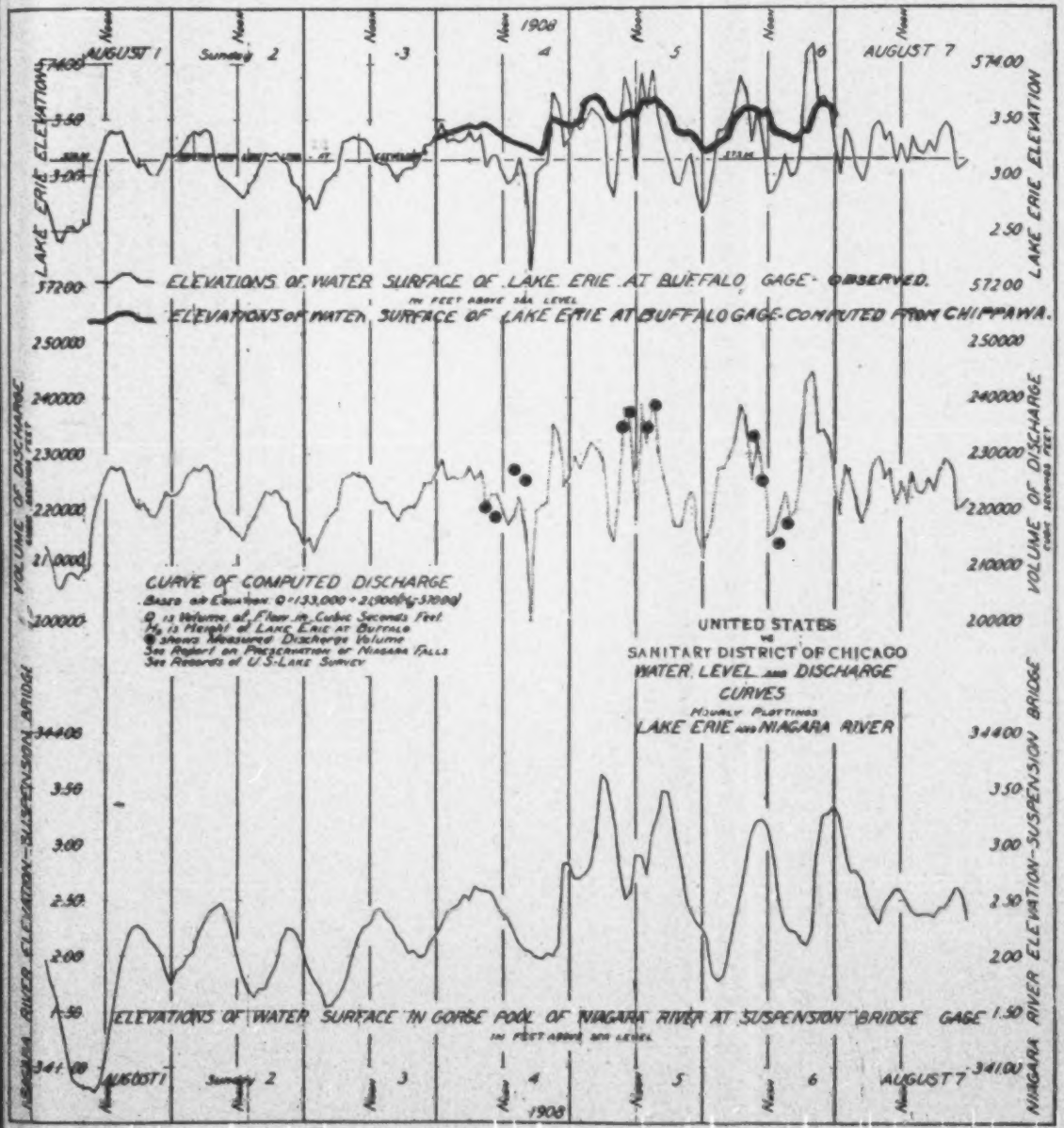
(Being Shenehon's Exhibit E-2 on Cross Examination)



Williams Exhibit 39-E 3.
(Being Shenehon's Exhibit E 3 on Cross Examination.)



(Being Shenehon's Exhibit E 4 on Cross Examination.)



WILLIAMS EX. 40.

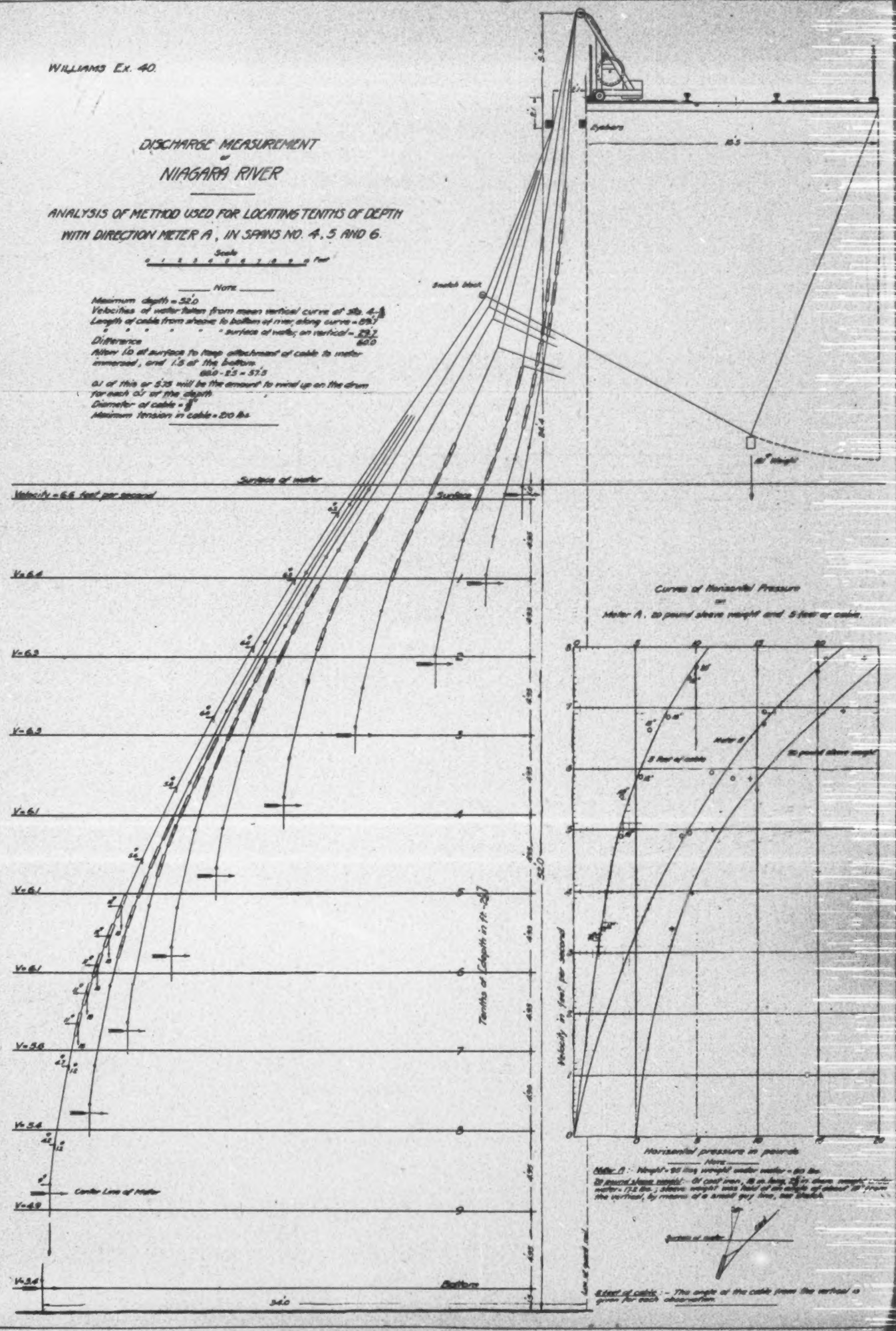
DISCHARGE MEASUREMENT
OF
NIAGARA RIVER

ANALYSIS OF METHOD USED FOR LOCATING TENTHS OF DEPTH WITH DIRECTION METER A, IN SPANS NO. 4, 5 AND 6.

Scale 0 1 2 3 4 5 6 7 8 9 10 Feet

Note

Maximum depth = 52.0
Velocities of water taken from mean vertical curve of Sts. 4-5
Length of cable from sheave to bottom of river along curve = 69.7
" " " " " surface of water, on vertical = 29.7
Difference 40.0
Allow 1.0 at surface to keep attachment of cable to meter immersed, and 1.5 at the bottom.
68.0 - 2.5 = 57.5
1/ of this or 5.75 will be the amount to wind up on the drum for each 1/ of the depth
Diameter of cable = 3/8"
Maximum tension in cable = 200 lbs.



PRESERVATION OF NIAGARA FALLS.

TABLE 47.—*Elevation of Lake Erie derived from discharge of Niagara River, International Bridge, Buffalo, N. Y.*

Number	Date	Wind		Change of Lake level during measurement		Fall Lake Erie to bridge (feet).	Meter U. S. Lake Survey	Discharge (cubic feet per second)	Lake Erie elevation (feet).		Difference (feet).	
		Direction	Estimated velocity (miles)	Rise (feet)	Fall (feet)				Computed	Observed	Lake, high	Lake, low
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*k*	*l*	*m*	*n*
	1907											
1	Oct. 21	.....	.....	0.02	0.13	4.95	2B	224,070	573.26	572.98	.....	0.28
2	Oct 22	SW.	25	.14	.00	4.94	2B	225,850	573.34	573.12	.....	.22
3	do	SW.	30	.09	.07	5.03	4A	235,600	573.75	573.54	.....	.21
4	do	SW.	10	.03	.41	4.93	1B	225,700	573.33	573.37	0.04	.....
5	Oct. 23	NW.	25–30	.13	.26	4.71	1B	202,510	572.26	572.42	.16	.....
6	do	NW.	30	.29	.01	4.75	1B	202,870	572.27	572.39	.12	.....
7	do	NW.	30–20	.21	.02	4.86	2B	211,320	572.67	572.61	.....	.03
8	Oct. 24	NW.	6	.03	.04	4.93	1B	212,030	572.70	572.66	.....	.04
9	do	NW	6	.00	.16	4.85	2B	215,140	572.84	572.57	.....	.27
10	do	SW.	8	.01	.11	4.84	2B	209,230	572.57	572.54	.....	.03
11	do	SW.	10	.16	.07	4.84	1B	207,170	572.47	572.41	.....	.03
12	Oct. 25	NW.	15–30	.00	.38	4.58	1B	205,550	572.40	572.57	.17	.....
13	do	NW.	20	.12	.01	4.71	2B	198,900	572.10	572.35	.25	.....
14	do	NW.	20	.31	.00	4.78	2B	207,120	572.48	572.54	.03	.....
15	Oct. 26	NE.	6	.02	.07	4.87	2B	205,470	572.40	572.49	.09	.....
16	do	NE.	6	.16	.04	4.86	1B	208,220	572.53	572.48	.....	.05
17	do	.....	.....	.06	.14	4.65	1B	196,450	571.99	572.10	.11	.....

WILLIAMS EXHIBIT 41—Continued.
Being Exhibit No. 1 of July 22, 1913.
PRESERVATION OF NIAGARA FALLS.

TABLE 47.—*Elevation of Lake Erie derived from discharge of Niagara River, International Bridge, Buffalo, N. Y.—Con.*

Number	Date	Wind		Change of Lake level during measurement		Fall Lake Erie to bridge (feet)	Meter U. S. Lake Survey	Discharge (cubic feet per second)	Lake Erie elevation (feet).		Difference (feet).	
		Direction	Estimated velocity (miles)	Rise (feet)	Fall (feet)				Computed.	Observed	Lake, high	Lake, low
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*k*	*l*	*m*	*n*
	1907											
18	Oct. 26			.02	.24	4.60	2B	190,050	571.72	571.94	.22	
19	Oct. 28	NW.	35	.03	.32	4.61	2B	208,370	572.53	572.48		.05
20	do	NW.	35	.07	.08	4.51	1B	196,210	571.98	572.13	.15	
21	do	NW.	35	.05	.02	4.69	1B	204,220	572.33	572.35	.02	
22	do	NW.	35	.32	.00	4.90	1B	211,430	572.67	572.63		.04
23	Oct. 29	NW.	10	.10	.04	4.92	1B	213,770	572.78	572.82	.04	
24	do	NW.	20	.03	.15	4.76	2B	210,540	572.64	572.64	.00	.00
25	do	NW.	25	.04	.29	4.74	2B	212,070	572.70	572.56		.14
26	Oct. 30	NE.	3	.14	.08	4.85	2B	212,380	572.72	572.44		.28
27	Oct. 31			.03	.06	4.84	2B	214,080	572.80	572.45		.35
28	do	NW.	2	.02	.10	4.81	2B	208,650	572.54	572.38		.16
29	do	SE.	3	.08	.16	4.67	2B	201,650	572.22	572.19		.03
30	Nov. 1	SE.	10	.13	.10	4.57	46A	208,330	572.53	572.32		.21
31	do	SE.	10	.15	.07	4.81	46A	211,080	572.66	572.40		.26
32	do	S.	2	.04	.09	4.77	46A	210,220	572.62	572.39		.23
33	do	S.	2	.05	.10	4.78	46A	209,780	572.60	572.38		.22
34	Nov. 2	S.	40	.33	.07	5.04	46A	219,360	573.04	572.80		.24
35	do	S.	40	.03	.33	4.99	46A	216,660	572.92	572.84		.08

36	do	S.	40	.02	.30	4.80	46A	207,810	572.50	572.55	.05	.....
37	Nov. 4	W.	4	.09	.01	5.01	46A	224,720	573.28	573.00	.....	.28
38	do	W.	4	.12	.20	4.85	46A	213,380	572.76	572.87	.11	.....
39	do	W.	7	.15	.02	4.79	46A	213,230	572.76	572.81	.05	.....
40	do	SW.	10	.04	.23	4.94	46A	218,840	573.02	572.93	.....	.09
	1908											
41	June 26	SE.	4	.00	.26	4.96	14B 1	228,820	573.46	573.39	.....	.07
42	June 27	SW.	3	.12	.01	5.17	14B 1	219,030	573.03	573.28	.25	.....
43	do	W.	5	.07	.03	5.23	1B 1	229,760	573.51	573.49	.....	.02
44	do	W.	5	.08	.10	5.20	1B 1	227,780	573.42	573.48	.06	.....
45	June 29	W.	8	.39	.15	4.90	1B 1	225,460	573.32	573.32	.00	.00
46	June 29	SW.	7–20	.10	.22	4.97	1B 1	227,050	573.39	573.39	.00	.00
47	June 30	SW.	8	.15	.17	5.11	14B 1	239,770	573.94	573.71	.....	.23
48	do	SW.	7–12	.08	.37	5.05	14B 1	236,730	573.80	573.60	.....	.20
49	do	SW.	15	.16	.24	4.99	1B 1	221,500	573.15	573.40	.25	.....
50	do	SW.	10	.14	.15	4.95	1B 1	219,980	573.08	573.28	.20	.....
51	July 2	E.	5	.07	.16	4.85	14B 4	213,620	572.77	572.92	.15	.....
52	do	NE.	6–25	.18	.07	4.88	14B 4	218,670	573.02	572.91	.....	.11
53	do	NE.	15	.06	.14	4.89	1B 1	208,410	572.54	572.85	.31	.....
54	do	NE.	20–7	.03	.17	4.88	1B 1	211,690	572.69	572.77	.08	.....
55	July 6	SW.	15	.06	.09	5.04	14B 4	230,740	573.54	573.52	.....	.02
56	do	SW.	12	.00	.27	4.96	14B 4	220,380	573.10	573.34	.24	.....
57	do	SW.	10	.03	.17	4.90	1B 1	220,590	573.11	573.23	.12	.....
58	do	SW.	15	.21	.12	4.85	1B 1	217,380	572.95	573.07	.12	.....
59	July 7	SW.	18	.12	.03	5.15	14B 4	222,100	573.17	573.54	.37	.....
60	do	SW.	18	.08	.19	5.20	14B 4	230,400	573.53	573.54	.01	.....
61	July 8	NW.	38	.51	.11	5.25	15B 1	239,400	573.92	573.80	.....	.12
62	do	NW.	38	.00	.66	5.00	15B 1	224,320	573.27	573.46	.19	.....
63	do	NW.	10	.12	.07	5.18	15B 1	231,060	573.55	573.63	.08	.....
64	do	SW.	25–40	.20	.13	5.06	15B 1	229,470	573.49	573.54	.05	.....
65	July 10	SW.	6	.04	.06	5.23	1B 1	223,380	573.23	573.30	.07	.....
66	do	SW.	6	.09	.07	5.20	1B 1	220,520	573.10	573.27	.17	.....
67	do	SW.	6	.01	.04	5.15	15B 3	230,220	573.52	573.30	.....	.22

WILLIAMS EXHIBIT 41—Continued.
Being Exhibit No. 1 of July 22, 1913.

PRESERVATION OF NIAGARA FALLS.

TABLE 47.—*Elevation of Lake Erie derived from discharge of Niagara River, International Bridge, Buffalo, N. Y.—Con.*

Number	Date	Wind		Change of Lake level during measurement		Fall Lake Erie to bridge (feet)	Meter U. S. Lake Survey	Discharge (cubic feet per second)	Lake Erie elevation (feet)		Difference (feet)	
		Direction	Estimated velocity (miles)	Rise (feet)	Fall (feet)				Computed.	Observed	Lake, high	Lake, low.
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*k*	*l*	*m*	*n*
	1908											
68	July 10	SW.	6	.05	.09	5.08	15B 3	222,770	573.20	573.23	.03	
69	July 16	SW.	5–15	.23	.02	5.04	1B 8	229,180	573.48	573.33		
70	do	SW.	8	.02	.11	5.03	1B 8	231,750	573.58	573.39		.15
71	July 18	SW.	10	.00	.03	4.88	1B 8	234,300	573.70	573.69		.19
72	do	SW.	10	.09	.31	4.69	1B 8	221,470	573.14	573.21	.07	.01
73	July 20	NW.	4	.00	.21	4.83	14B 7	223,100	573.22	573.24	.02	
74	do	SW.	8	.06	.13	4.77	14B 7	222,480	573.19	573.10		
75	do	NW.	3	.09	.02	4.83	1B 8	222,340	573.18	573.00		.09
76	July 21		0	.26	.43	4.81	14B 7	216,400	572.91	573.16	.25	.18
77	do	NW.	10	.14	.21	4.73	14B 7	213,930	572.78	572.91	.13	
78	do	NW.	10	.21	.03	4.80	14B 7	215,200	572.85	573.08	.23	
79	July 22	SW.	5	.11	.07	4.95	14B 7	228,150	573.43	573.38		
80	do	SW.	12	.10	.02	4.94	1B 8	231,250	573.56	573.42		.05
81	do	SW.	10	.05	.10	4.83	1B 8	224,090	573.26	573.29	.03	.14
82	do	NW	5	.04	.09	4.81	1B 8	226,780	573.37	573.20		
83	July 23	NW.	5	.16	.08	4.80	1B 8	221,610	573.14	573.00		.17
84	do	NW.	5	.06	.11	4.84	1B 8	221,950	573.16	573.08		.14
85	do	NE.	8	.18	.14	4.83	1B 8	222,880	573.20	573.12		.08

86	do	NE.	8	.06	.06	4.81	1B 8	222,660	573.19	573.09	.....	.10
87	July 24	NE.	5	.06	.03	4.78	14B 7	213,120	572.75	572.84	.09	.....
88	do	NE.	5	.14	.12	4.80	14B 7	208,520	572.54	572.87	.33	.....
89	do	NE.	12	.15	.65	4.70	1B 8	216,060	572.90	572.85	.....	.05
90	do	NE.	10	.18	.25	4.72	1B 8	212,990	572.74	572.72	.....	.02
91	July 25	NE.	4	.14	.12	4.86	14B 7	220,410	573.09	573.20	.11	.....
92	do	NE.	6	.15	.19	4.72	14B 7	218,340	573.00	573.00	.00	.00
93	do	NE.	10	.13	.18	4.84	1B 8	225,010	573.30	573.08	.....	.22
94	July 27	.....	0	.05	.01	4.75	1B 8	221,150	573.13	573.02	.....	.11
95	do	NE.	3	.05	.02	4.76	1B 8	216,700	572.93	573.00	.07	.....
96	July 29	SW.	5	.06	.05	4.81	14B 7	221,010	573.13	573.10	.....	.03
97	do	SW.	3	.06	.04	4.86	14B 7	226,680	573.37	573.18	.....	.19
98	July 30	SW.	8	.02	.07	4.85	14B 7	224,840	573.29	573.21	.....	.08
99	do	SW.	8	.02	.09	4.83	14B 7	221,770	573.16	573.15	.....	.01
100	do	SW.	10	.10	.03	4.83	1B 8	226,800	573.38	573.15	.....	.23
101	July 31	SW.	8	.03	.06	4.84	1B 8	227,870	573.42	573.20	.....	.22
102	do	NW	15	.00	.03	4.81	1B 8	222,820	573.20	573.20	.....	.00
103	do	NW	15	.04	.08	4.74	1B 8	223,320	573.22	573.08	.....	.14
104	do	NW.	15	.12	.00	4.78	1B 8	226,370	573.35	573.11	.....	.24
105	Aug. 1	NE	10	.26	.01	4.90	14B 7	212,960	572.74	572.67	.....	.07
106	do	NE.	18	.22	.01	5.10	14B 7	221,310	573.13	573.07	.....	.06
107	Aug. 4	SW.	15	.04	.28	4.79	14B 7	220,370	573.09	573.18	.09	.....
108	do	SW.	15- 8	.09	.07	4.82	14B 7	218,710	573.02	573.18	.16	.....
109	do	SW.	15	.17	.03	4.76	1B 8	227,110	573.39	573.06	.....	.33
110	do	SW.	8	.14	.05	4.71	1B 8	225,180	573.31	572.98	.....	.33
111	Aug. 5	SW.	8	.64	.06	4.98	1B 8	234,750	573.72	573.39	.....	.33
112	do	SW.	8	.02	.48	5.06	1B 8	237,330	573.83	573.61	.....	.22
113	do	SW.	35	.25	.80	5.05	14B 7	234,570	573.71	573.77	.06	.....
114	do	SW.	20	.30	.47	5.02	14B 7	238,630	573.89	573.88	.....	.01
115	Aug. 6	SW.	50	.06	.02	4.86	14B 7	233,020	573.64	573.56	.....	.08
116	do	SW.	20	.00	.69	4.71	14B 7	225,050	573.30	573.27	.....	.03
117	do	SW.	30	.29	.03	4.67	1B 8	213,850	572.78	572.94	.16	.....
118	do	SW.	20	.05	.26	4.77	1B 8	217,220	572.94	573.03	.09	.....

WILLIAMS EXHIBIT 42

Being Complainant's Exhibit 4 of July 22, 1913
Cross-Examination of Gardner S. Williams

TABLE 1

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT BUFFALO, N. Y., DURING MONTH OF NOVEMBER 1906.

Hour	1	2	3	4	5	6	7	8	9	10	11
1	571.86	571.92	571.98	571.15	571.78	571.64	571.88	571.87	571.63	571.77	571.69
2	1.87	1.85	2.04	1.14	1.85	1.69	1.83	1.83	1.84	1.94	1.60
3	1.92	1.85	2.01	1.14	1.87	1.76	1.70	1.84	1.77	1.93	1.62
4	1.86	1.75	1.99	1.38	2.01	1.88	1.78	1.83	1.95	2.03	1.55
5	1.88	1.73	1.93	1.02	1.92	1.90	1.77	1.90	2.12	2.32	1.49
6	1.89	1.72	1.85	1.32	1.88	1.89	1.69	1.89	1.98	2.50	1.49
7	1.83	1.75	1.75	1.25	1.86	1.96	1.71	1.63	2.03	2.28	1.50
8	1.85	1.82	1.74	1.48	1.75	1.95	1.80	1.83	1.80	2.44	1.65
9	1.83	1.80	1.75	1.24	1.77	1.93	1.81	1.78	1.76	2.55	1.73
10	1.82	1.88	1.75	1.23	1.70	2.00	1.83	1.70	1.73	2.55	1.80
11	1.77	1.93	1.74	1.36	1.74	1.82	1.82	1.61	1.63	2.62	1.88
12	1.72	1.92	1.82	1.45	1.82	1.79	1.85	1.68	1.81	2.63	1.86
13	1.80	1.92	1.92	1.32	1.81	1.81	1.86	1.74	1.92	2.66	1.70
14	1.86	1.96	1.85	1.18	1.82	1.76	1.90	1.77	1.94	2.50	1.59
15	1.88	2.00	1.93	1.25	1.88	1.83	1.87	1.83	2.41	2.88	1.72
16	1.89	1.96	1.98	1.39	2.01	1.81	1.90	1.78	2.40	3.02	1.86
17	1.87	1.94	1.88	1.10	1.92	1.89	1.95	1.91	3.28	2.47	1.83
18	1.91	1.80	1.85	1.12	1.93	1.79	1.89	1.73	3.55	2.11	1.82
19	1.96	1.82	1.76	1.09	1.88	1.81	1.80	1.75	3.12	2.21	1.85
20	1.96	1.83	1.70	1.05	1.80	1.90	1.76	1.60	2.63	2.09	1.84
21	1.89	1.78	1.60	1.18	1.64	1.98	1.75	1.51	2.35	2.00	1.72
22	1.92	1.82	1.50	1.31	1.72	2.00	1.85	1.55	2.61	1.95	1.82
23	1.95	1.78	1.28	1.51	1.71	1.92	1.80	1.47	1.88	2.08	2.00
24	571.90	571.95	571.25	571.60	571.78	571.88	571.70	571.71	571.53	571.92	571.80
Mean	572.09	572.07	572.01	571.48	572.05	572.08	572.08	571.98	572.37	572.83	571.98

Add 22 ft. to all readings from 1st to 25th, inclusive. Datum 593.81 instead of 570.08. Daily means have been corrected.

TABLE 1

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT BUFFALO, N. Y., DURING MONTH OF NOVEMBER 1906.

Hour	12	13	14	15	16	17	18	19	20	21	22
1	571.82	572.26	572.00	571.80	571.99	571.50	571.53	571.91	571.78	571.22	575.54
2	1.99	2.28	1.98	1.71	1.95	1.38	1.68	2.22	1.54	1.53	6.60
3	1.94	2.28	1.92	1.50	2.02	1.47	1.65	2.16	1.38	1.59	7.20
4	2.03	2.29	2.05	1.38	2.05	1.34	1.68	2.43	1.18	1.50	7.10
5	2.12	2.04	2.27	1.30	2.05	1.20	2.14	2.22	1.17	1.25	7.30
6	2.10	2.04	2.27	1.28	2.02	1.38	1.91	2.49	1.61	1.27	5.47
7	2.05	2.05	2.16	1.31	1.87	1.03	2.09	2.38	1.35	1.07	5.22
8	2.72	2.10	2.26	1.43	1.90	1.12	2.18	1.78	1.36	0.85	4.61
9	2.04	2.13	2.14	1.54	1.82	1.18	2.17	1.73	1.25	0.72	4.02
10	2.01	2.18	2.07	1.71	1.72	1.41	2.16	1.69	1.36	1.12	3.62
11	1.87	2.31	2.06	1.82	1.78	1.35	2.05	1.92	1.50	1.10	4.12
12	1.73	2.30	2.00	1.83	1.78	1.56	2.14	1.83	1.32	1.29	4.13
13	1.60	2.35	1.94	1.94	1.89	2.00	2.09	1.93	1.30	1.39	3.82
14	1.64	2.31	1.79	1.86	1.97	2.36	2.35	2.00	1.50	1.52	3.76
15	1.67	2.15	1.75	1.73	2.10	2.48	1.97	1.85	1.70	1.65	4.08
16	1.68	2.16	1.74	1.65	2.13	2.09	2.31	1.98	1.28	1.95	3.86
17	1.68	2.18	1.70	1.58	2.09	2.25	3.05	1.88	1.12	1.66	3.66
18	1.76	2.11	1.76	1.46	1.99	2.22	3.18	1.91	1.40	1.53	3.31
19	1.81	1.99	1.80	1.44	1.92	1.92	3.36	1.98	1.30	1.58	3.38
20	1.83	2.02	1.86	1.59	1.83	1.50	2.57	1.93	1.22	1.71	3.26
21	1.86	2.05	1.80	1.60	1.72	1.63	2.38	1.98	1.05	1.81	3.22
22	1.93	1.90	1.86	1.54	1.68	1.68	2.00	2.04	1.42	3.45	2.65
23	1.99	1.90	1.95	1.63	1.56	1.20	1.84	2.03	1.35	4.12	2.62
24	572.20	571.92	571.85	571.92	571.52	571.59	572.00	571.90	571.29	575.31	572.49
Mean	572.11	572.36	572.18	571.83	572.11	571.84	572.41	572.23	571.58	571.98	574.60

Notes on condition of record.....

WILLIAMS EXHIBIT 42

Being Complainant's Exhibit 4 of July 22, 1913
Cross-Examination of Gardner S. Williams

TABLE 1

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT BUFFALO, N. Y., DURING MONTH OF NOVEMBER 1906.

Hour	23	24	25	26	27	28	29	30	31	
1	572.00	572.53	572.99	571.87	572.50	572.56	572.33	572.72	.....	Elevation of Zero of Staff Gage, 573.09 (Levels of 1903.)
2	1.90	2.60	2.96	2.00	3.58	2.65	2.08	2.64	.....	
3	2.01	2.38	2.93	2.10	4.35	2.83	2.15	2.54	.....	
4	2.16	2.30	2.85	2.10	4.77	3.08	1.90	2.50	.....	
5	2.22	2.42	2.57	2.38	4.33	3.02	2.09	2.59	.....	Date of last inspection, Aug. 7 and Nov. 20, 1906.
6	2.42	2.41	2.66	2.24	5.12	3.20	1.96	2.61	.....	
7	2.50	2.18	2.81	2.16	4.25	3.00	1.96	2.64	.....	
8	2.64	2.30	2.50	2.25	4.04	3.37	2.09	2.60	.....	
9	2.77	2.39	2.53	1.94	3.76	3.57	2.11	2.73	.....	
10	2.77	2.27	2.74	1.63	3.68	3.37	2.16	2.98	.....	
11	2.63	2.14	2.74	1.92	3.49	3.25	2.18	3.13	.....	
12	2.55	2.27	2.55	2.13	2.70	2.67	2.27	2.92	.....	
13	2.48	2.43	2.67	2.04	2.73	2.67	2.33	2.96	.....	
14	2.26	2.73	2.64	2.23	3.18	2.54	2.36	3.10	.....	
15	2.26	2.72	2.43	2.15	3.13	2.46	2.38	3.17	.....	
16	2.33	2.68	2.30	2.53	3.10	2.46	2.12	3.29	.....	
17	2.30	2.85	2.28	3.27	2.89	2.28	2.26	3.40	.....	
18	2.37	2.95	2.17	3.46	3.02	2.35	2.30	3.19	.....	
19	2.47	2.74	2.09	3.10	2.55	2.15	2.30	3.52	.....	
20	2.61	2.60	1.85	3.11	2.27	2.17	2.22	3.55	.....	
21	2.58	2.67	1.64	3.22	2.49	2.41	2.43	3.38	.....	
22	2.63	2.74	1.60	2.75	2.66	2.45	2.47	3.39	.....	
23	2.78	2.78	1.80	2.74	2.54	2.57	2.40	3.10	.....	
24	572.51	573.03	571.55	572.54	572.35	572.34	572.45	573.35	.....	Monthly Mean
Mean	572.64	572.77	572.62	572.41	573.31	572.78	572.22	573.00	.....	572.810

WILLIAMS EXHIBIT 42
Being Complainant's Exhibit 4 of July 22, 1913
Cross-Examination of Gardner S. Williams

TABLE 1

ELEVATION OF DATUM LINE AS DERIVED FROM REFERENCE GAGE.

Date	Time	Elev. of W. S. by Ref. Gage	Scaled height above Datum	Elevation of Datum		Remarks
Nov. 2	10.25	572.09	.....	570.02	.....	.....
3	18.52	1.99	.....	0.02	.....	.....
5	16.45	2.09	.....	0.00	.....	.....
6	16.45	2.09	.....	0.04	.....	.....
7	16.30	2.09	.....	0.02	.....	.....
8	14.05	1.99	.....	0.03	.....	.....
9	16.30	2.59	.....	0.00	.....	.....
11	16.20	2.09	.....	0.04	.....	.....
12	16.45	1.89	.....	0.06	.....	.....
14	18.40	1.99	.....	570.04	.....	.....
15	16.30	1.79	.....	569.98	.....	.....
17	16.00	2.09	.....	569.83	.....	.....
20	15.50	1.69	.....	570.01	.....	.....
21	15.45	1.99	.....	569.98	.....	.....
24	16.40	2.99	.....	570.00	.....	.....
26	16.15	3.09	.....	570.35	.....	.....
27	16.04	2.89	.....	569.90	.....	.....
29	8.35	2.29	.....	570.12	.....	.....
29	9.17	572.29	.....	570.12	.....	.....
			Mean	570.03		

Max. at.....hour.....day.....
Min. at.....hour.....day.....

REDUCTION OF RECORD

Vertical Scale of Record, 1 inch = 1 foot.
Horizontal Scale of Record, 2 in. = 1 hour.
Record prepared by Lockwood.
Record scaled by Lockwood.
Water levels recorded by Lawton.
Daily and Mo. Means by.....
Means checked by.....

Elevation of Datum Line used in scaling this record, 570.03.

Williams Exhibit 42.

Cross X Wms. No. 4 x

WILLIAMS EXHIBIT 42
Being Complainant's Exhibit 4 of July 22, 1913
Cross-Examination of Gradner S. Williams

TABLE 2

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT CHIPPAWA, ONT., DURING MONTH OF NOVEMBER, 1906.

Hour	1	2	3	4	5	6	7	8	9	10	11
1	562.38	562.44	562.39	562.24	562.07	562.30	562.35	562.31	562.21	562.62	562.52
2	2.39	2.45	2.39	2.19	2.12	2.29	2.35	2.31	2.21	2.63	2.47
3	2.39	2.45	2.40	2.14	2.16	2.28	2.35	2.31	2.21	2.50	2.43
4	2.41	2.44	2.43	2.10	2.21	2.28	2.35	2.31	2.23	2.48	2.38
5	2.41	2.43	2.43	2.09	2.25	2.28	2.34	2.32	2.25	2.45	2.35
6	2.42	2.42	2.43	2.09	2.28	2.29	2.33	2.32	2.27	2.45	2.32
7	2.43	2.40	2.43	2.08	2.29	2.29	2.32	2.32	2.30	2.49	2.29
8	2.43	2.38	2.42	2.08	2.30	2.30	2.30	2.31	2.31	2.51	2.28
9	2.43	2.38	2.40	2.09	2.31	2.31	2.28	2.30	2.31	2.51	2.27
10	2.43	2.38	2.39	2.11	2.30	2.33	2.28	2.29	2.32	2.55	2.27
11	2.42	2.38	2.38	2.10	2.31	2.33	2.28	2.29	2.31	2.57	2.27
12	2.42	2.39	2.36	2.09	2.31	2.33	2.28	2.28	2.31	2.60	2.28
13	2.40	2.39	2.34	2.10	2.31	2.33	2.29	2.27	2.30	2.62	2.29
14	2.39	2.40	2.35	2.12	2.31	2.33	2.28	2.27	2.30	2.65	2.30
15	2.38	2.40	2.35	2.11	2.30	2.32	2.28	2.26	2.31	2.66	2.30
16	2.39	2.41	2.35	2.10	2.30	2.30	2.29	2.25	2.34	2.65	2.30
17	2.38	2.42	2.36	2.09	2.31	2.30	2.29	2.26	2.40	2.70	2.30
18	2.39	2.43	2.36	2.09	2.33	2.31	2.30	2.27	2.46	2.72	2.30
19	2.40	2.42	2.36	2.08	2.33	2.31	2.31	2.28	2.64	2.68	2.31
20	2.41	2.42	2.36	2.05	2.34	2.32	2.32	2.28	2.75	2.63	2.33
21	2.42	2.41	2.36	2.04	2.33	2.31	2.32	2.27	2.77	2.62	2.34
22	2.42	2.39	2.35	2.03	2.33	2.32	2.31	2.25	2.74	2.58	2.34
23	2.42	2.39	2.32	2.02	2.32	2.34	2.31	2.22	2.72	2.55	2.33
24	562.44	562.39	562.28	562.04	562.31	562.35	562.31	562.22	562.69	562.53	562.33
Mean	562.41	562.41	562.37	562.09	562.28	562.31	562.31	562.26	562.40	562.58	562.33
	2.50	2.38	2.35	2.08	2.27	2.30	2.30	2.32	2.55	2.64	2.32

TABLE 2

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT CHIPPAWA, ONT., DURING MONTH OF NOVEMBER, 1906.

Hour	12	13	14	15	16	17	18	19	20	21	22
1	562.34	562.43	562.49	562.36	562.22	561.68	561.63	562.00	561.80	561.49	562.50
2	2.35	2.48	2.48	2.36	2.27	1.67	1.63	1.97	1.80	1.49	2.87
3	2.35	2.52	2.47	2.36	2.29	1.63	1.61	1.97	1.78	1.49	3.07
4	2.35	2.54	2.47	2.33	2.32	1.61	1.62	1.95	1.74	1.52	3.63
5	2.38	2.56	2.47	2.30	2.33	1.59	1.63	1.96	1.68	1.55	3.91
6	2.40	2.58	2.48	2.25	2.35	1.55	1.67	1.97	1.62	1.55	4.05
7	2.42	2.56	2.49	2.21	2.37	1.53	1.71	1.98	1.59	1.54	4.01
8	2.42	2.55	2.50	2.17	2.37	1.50	1.74	1.98	1.57	1.53	4.01
9	2.43	2.54	2.51	2.14	2.37	1.47	1.78	1.97	1.53	1.49	3.89
10	2.43	2.54	2.52	2.14	2.37	1.46	1.82	1.89	1.51	1.48	3.67
11	2.44	2.53	2.52	2.15	561.72	1.45	1.84	1.84	1.49	1.44	3.51
12	2.43	2.53	2.51	2.19	1.71	1.45	1.85	1.82	1.49	1.46	3.41
13	2.42	2.56	2.51	2.22	1.72	1.45	1.85	1.80	1.50	1.47	3.41
14	2.38	2.58	2.49	2.25	1.70	1.50	1.89	1.79	1.50	1.49	3.35
15	2.36	2.59	2.47	2.28	1.70	1.58	1.89	1.79	1.48	1.55	3.21
16	2.34	2.60	2.43	2.27	1.71	1.68	1.90	1.79	1.51	1.61	3.17
17	2.33	2.59	2.40	2.28	1.75	1.72	1.89	1.78	1.53	1.68	3.13
18	2.30	2.58	2.38	2.27	1.78	1.74	1.95	1.78	1.51	1.73	3.19
19	2.30	2.57	2.37	2.27	1.79	1.77	2.06	1.76	1.50	1.74	3.00
20	2.32	2.55	2.37	2.24	1.79	1.79	2.17	1.76	1.49	1.74	2.95
21	2.34	2.54	2.35	2.22	1.78	1.77	2.20	1.76	1.50	1.76	2.90
22	2.34	2.53	2.35	2.21	1.77	1.73	2.14	1.75	1.47	1.75	2.85
23	2.36	2.52	2.35	2.21	1.74	1.72	2.11	1.77	1.47	1.85	2.75
24	562.40	562.50	562.35	562.21	561.71	561.68	562.05	561.79	561.47	562.13	562.65
Mean	562.37	562.54	562.45	562.25	562.34	562.23	562.48	562.48	562.18	562.23	563.92
	2.40	2.54	2.44	2.25	2.40	2.25	2.57	2.47	2.11	2.33	3.79

All readings after 10th hour, Nov. 16, are 0.62 ft. too small, except daily means, which have been corrected. The wrong elevation for zero of gage was used. S. T. H. & F. L.

Notes on condition of record.....

Williams Exhibit 42.

WILLIAMS EXHIBIT 42

Being Complainant's Exhibit 4 of July 22, 1913
Cross-Examination of Gardner S. Williams

TABLE 2

HOURLY WATER LEVELS AS RECORDED BY SELF-REGISTERING GAGE AT CHIPPAWA, ONT., DURING MONTH OF NOVEMBER, 1906.

Hour	23	24	25	26	27	28	29	30	31	
1	562.57	562.27	562.29	561.84	562.14	562.11	561.94	561.89	.....	Elevation of Zero of Staff Gage, 567.639. (Levels of 1903.)
2	2.45	2.27	2.32	1.81	2.10	2.10	1.93	1.92	.....	
3	2.31	2.27	2.34	1.80	2.13	2.08	1.91	1.96	.....	
4	2.23	2.26	2.35	1.80	2.29	2.09	1.88	1.95	.....	Date of last inspection.....
5	2.20	2.23	2.35	1.79	2.50	2.14	1.85	1.96	.....	.....
6	2.17	2.20	2.35	1.82	2.66	2.17	1.82	1.96	.....	
7	2.16	2.19	2.32	1.84	2.77	2.22	1.81	1.98	.....	
8	2.17	2.17	2.32	1.84	2.87	2.22	1.78	1.99	.....	
9	2.19	2.14	2.30	1.83	2.85	2.26	1.76	2.01	.....	
10	2.23	2.14	2.28	1.81	2.82	2.30	1.76	2.03	.....	
11	2.27	2.13	2.28	1.77	2.81	2.34	1.77	2.07	.....	
12	2.27	2.11	2.27	1.72	2.75	2.35	1.79	2.04	.....	
13	2.28	2.09	2.28	1.73	2.62	2.31	1.80	2.06	.....	
14	2.28	2.08	2.26	1.73	2.50	2.27	1.81	2.16	.....	
15	2.26	2.10	2.24	1.74	2.46	2.19	1.83	2.20	.....	
16	2.21	2.15	2.24	1.77	2.45	2.18	1.86	2.22	.....	
17	2.20	2.18	2.20	1.79	2.41	2.17	1.87	2.25	.....	
18	2.19	2.21	2.15	1.90	2.38	2.05	1.86	2.29	.....	
19	2.17	2.26	2.11	2.03	2.36	2.03	1.85	2.29	.....	
20	2.15	2.28	2.07	2.11	2.31	1.98	1.86	2.30	.....	
21	2.19	2.28	2.02	2.13	2.21	1.94	1.85	2.34	.....	
22	2.21	2.27	1.96	2.17	2.17	1.93	1.86	2.37	.....	
23	2.22	2.27	1.90	2.18	2.14	1.94	1.87	2.39	.....	
24	562.26	562.27	561.88	562.16	562.14	561.96	561.87	562.40	.....	
Mean	562.86 2.70	562.82 2.77	562.83 2.99	562.50 2.57	563.07 3.07	562.76 2.75	562.46 2.47	562.75 2.90	.....	Monthly Mean 562.510

WILLIAMS EXHIBIT 42

Being Complainant's Exhibit 4 of July 22, 1913.
Cross-Examination of Gardner S. Williams

TABLE 2

ELEVATION OF DATUM LINE AS DERIVED FROM REFERENCE GAGE.

Date	Time	Elev. of W. S. by Ref. Gage	Scaled height above Datum	Elev. of Datum 1" Scale	Elev. of Datum 3" Scale	Remarks
Nov. 16	.....	561.73	.....	555.90	560.39	.....
Nov. 23	.....	562.25	.....	555.98	560.38	.....
Nov. 24	.....	562.14	.....	556.02	560.39	.....
.....	.....	.....	Mean	555.97	560.39	.....
.....	.....	.....	.....	0.62	0.62	.....
.....	.....	.....	Corr.	556.59	561.01	.....
Nov. 30	.....	562.20	.....	556.00	560.39	.....
Dec. 1	.....	2.30	.....	556.00	560.40	.....
Dec. 3	.....	1.98	.....	555.98	560.41	.....
.....	.....	.....	Mean	555.99	560.40	.....
.....	.....	.....	.....	0.62	0.62	.....
.....	.....	.....	Corr.	556.61	561.02	.....

Max. at 6 hour, 22 day, 564.67
Min. at 11 hour, 21 day, 562.02

REDUCTION OF RECORD

Vertical Scale of Record. . . . inches=1 foot
Horizontal Scale of Record, 2 in.=1 hour.
Record prepared by Lockwood.
Record Scaled by Lockwood.
Water levels recorded by Lawton.
Daily and Monthly Means by Lockwood.
Means checked by Lawton.
Harding & Lockwood check before 16th.
Elevation of Datum Line used in scaling this record.
Nov. 16–27, 560.39.
Nov. 27–30, 560.40.